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(71) Demandeur/Applicant:
RENOVO LIMITED, GB

(72) Inventeurs/Inventors:
FERGUSON, MARK WILLIAM JAMES, GB;
LAVERTY, HUGH, GB;
OCCLESTON, NICHOLAS, GB;
O'KANE, SHARON, GB;
NIELD, KERRY, GB

(74) Agent: MARKS & CLERK

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(54) Title: WNT3A FOR INHIBITION OF SCARRING

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Provided is WNT3A, or a therapeutically effective fragment or derivative thereof, for use as a medicament for the prevention, reduction or inhibition of scarring. Also provided is a method of preventing, reducing or inhibiting scarring, the method comprising administering a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, to a patient in need of such prevention, reduction or inhibition. The methods and medicaments of the invention are suitable for use in the prevention, reduction or inhibition of scarring arising as a result of healing of a wound, or scarring associated with a fibrotic disorder. The methods and medicaments disclosed are of particular use in preventing, reducing or inhibiting scarring of the skin.

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(71) Applicant *(for all designated States except US)*: **RENOVO LIMITED** [GB/GB]; Incubator Building, 48 Grafton Street, Manchester M13 9XX (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **FERGUSON, Mark, William, James** [GB/GB]; Renovo Limited, The Manchester Incubator Building, Grafton Street, Manchester M13 9XX (GB). **LAVERTY, Hugh** [GB/GB]; Renovo Limited, Incubator Building, 48 Grafton Street, Manchester M13 9XX (GB). **OCCLESTON, Nicholas** [GB/GB]; Renovo Limited, Incubator Building, 48 Grafton Street, Manchester M13 9XX (GB). **O'KANE, Sharon** [GB/GB]; Renovo Limited, Incubator Building, 48 Grafton Street, Manchester M13 9XX (GB). **NIELD, Kerry** [GB/GB]; Renovo Limited, Incubator Building, 48 Grafton Street, Manchester M13 9XX (GB).

(74) Agent: **ARMSTRONG, Iain, Cheshire**; Marks & Clerk, Sussex House, 83-85 Mosley Street, Manchester M2 3LG (GB).

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# WNT3A FOR INHIBITION OF SCARRING

The present invention relates to medicaments for the prevention, reduction or inhibition of scarring. The invention also provides methods for the prevention, reduction or inhibition of scarring.

Clinical approaches to wound management will generally depend on the desired outcome. This outcome may, for example, be considered with reference to the degree of scarring occurring, or with reference to the speed at which a wound heals. In management of some wounds control of the degree of scarring that occurs is of primary importance, while increasing the speed of wound healing is of much lesser importance. In management of other wounds increasing the speed of wound healing is of primary importance, while controlling the degree of scarring occurring is of much lesser importance.

A scar may be defined as "fibrous connective tissue that forms at the site of injury or disease in any tissue of the body" (the scarring response is common throughout all adult mammals). Scarring may result from healing of a wound, or through the deposition of scar tissue associated with fibrotic disorders. The scarring response is conserved between the majority of tissue types and in each case leads to the same result, formation of fibrotic tissue termed "a scar". Many different processes are at work during the scarring response, and much research has been conducted into discovering what mediates these processes, and how they interact with each other to produce the final outcome.

The scarring response has arisen as the evolutionary solution to the biological imperative to prevent the death of a wounded animal. Thus, to overcome the risk of mortality due to infection or blood loss, the body reacts rapidly to repair the damaged area, rather than attempt to regenerate the damaged tissue.

In the case of a scar that results from healing of a wound, the scar may be defined as the structure produced as a result of the reparative response. Since the injured tissue is not regenerated to attain the same tissue architecture present before wounding, a scar may be identified by virtue of its abnormal morphology as compared to unwounded tissue. Such

scars are composed of connective tissue deposited during the healing process. A scar may comprise connective tissue that has an abnormal organisation (as seen in scars of the skin) and/or connective tissue that is present in an abnormally increased amount. Most scars consist of both abnormally organised and excess connective tissue.

The abnormal structure of scars may be observed with reference to both their internal structure (which may be determined by means of microscopic analysis) and their external appearance (which may be assessed macroscopically).

Extracellular matrix (ECM) molecules comprise the major structural component of both "normal" (unwounded) and scarred skin. In normal skin these molecules form fibres that have a characteristic random arrangement that is commonly referred to as "basket-weave". In general the fibres observed within normal skin are of larger diameter than those seen in scars. Fibres in scars also exhibit a marked degree of alignment with each other as compared to the random arrangement of fibres in normal skin. Both the size and arrangement of ECM may contribute to the scars altered mechanical properties, most notably increased stiffness, when compared with normal skin.

Viewed macroscopically, scars may be depressed below the surface of the surrounding tissue, or elevated above the surface of the undamaged skin. Scars may be relatively darker coloured than the normal skin (hyperpigmentation) or may have a paler colour (hypopigmentation) than their surroundings. Either hyperpigmented or hypopigmented scars constitute a readily apparent cosmetic defect. It is also known that scars may be redder than unwounded skin, causing them to be noticeable and cosmetically unacceptable. It has been shown that the cosmetic appearance of a scar is one of the major factors contributing to the psychological impact of scars upon the sufferer, and that these effects can remain long after the cause of the scar, be it either a wound or a fibrotic disorder, has passed.

Scars may also have deleterious physical effects upon the sufferer. These effects typically arise as a result of the mechanical differences between scars and normal skin. The abnormal structure and composition of scars mean that they are typically less flexible than normal skin.

As a result scars may be responsible for impairment of normal function (such as in the case of scars covering joints which may restrict the possible range of movement) and may retard normal growth if present from an early age.

Scarring may also occur at many other body sites, and the effects of scarring at these sites may also be deleterious to the sufferer. For example, scarring in the eye (whether as a result of accidental injury, surgical intervention, or a fibrotic disorder) can impair vision and even lead to blindness. Scarring of the internal organs may lead to the formation of strictures and adhesions that significantly or totally impair function of the organ in question. Scarring of tendons and ligaments may cause lasting damage to these organs, and thereby reduce the motility or function of associated joints. Scarring associated with blood vessels, and particularly the valves of the heart, may occur after injury or surgery. Scarring of blood vessels may lead to restenosis, which causes a narrowing of the blood vessel and thus reduces the flow of blood through the scarred area. Scarring in the central and peripheral nervous system may prevent transmission along the nerve and may prevent or reduce reconnection of damaged nerve tissue, and/or functional neuronal transmission.

The effects outlined above may all arise as a result of the normal progression of the wound healing response (in the case of scars that result from healing of a wound). There are, however, many ways in which the scarring response may be abnormally altered; and these are frequently associated with even more damaging results.

One way in which the scarring response may be altered is through the production of abnormal excessive scarring (commonly referred to as pathological scarring).

Hypertrophic scars are a common form of pathological scarring, and have marked adverse effects on the sufferer. Hypertrophic scars are elevated above the normal surface of the skin and contain excessive collagen arranged in an abnormal pattern. As a result, such scars are often associated with a marked loss of normal mechanical function. This may be exacerbated by the tendency of hypertrophic scars to undergo contraction after their formation, an activity normally ascribed to their abnormal expression of muscle-related

proteins (particularly smooth-muscle actin). Children suffer from an increased likelihood of hypertrophic scar formation, particularly as a result of burn injuries.

Keloids are another common form of pathological scarring. Keloid scars are not only elevated above the surface of the skin but also extend beyond the boundaries of the original injury. Keloids contain excessive connective tissue that is organised in an abnormal fashion, normally manifested as whorls of collagenous tissue. The causes of keloid formation are open to conjecture, but it is generally recognised that some individuals have a genetic predisposition to their formation. Both hypertrophic scars and keloids are particularly common in those of the African Continental Ancestry Group or Asian Continental Ancestry Group.

A further common form of pathological scarring is pterygium in which a wedge-shaped fibrotic outgrowth of subconjunctival tissue may grow to the border of the cornea or beyond. Pterygium is more frequent among those frequently exposed to strong sunlight or dusty conditions.

Connective tissue contractures are a further common form of pathological scarring, in which normally elastic connective tissues are replaced by inelastic fibrous tissue. Hypertrophic scarring of connective tissue is observed in Dupuytren's Contracture, in which a thick "scar like" band forms along the palm of the hand due to hyperplasia of the palmar fascia.

Although scarring may be defined as the production of the structure that remains on healing of a wound, similar disturbances of the extracellular matrix may also give rise to scarring associated with a number of medical conditions known as fibrotic disorders. In these disorders excessive fibrosis leads to pathological derangement and malfunctioning of tissue. Scars associated with fibrotic disorders are characterised by the accumulation of fibrous tissue (predominately collagens, as described above) in an abnormal fashion within the damaged tissue. Accumulation of such fibrous tissues may result from a variety of disease processes, all of which lead to the same end result. The biological and pathological processes underlying the development of scars associated with fibrotic

disorders are sufficiently similar to those involved in the formation of scars resulting from healing of a wound that those compounds that may be used to prevent, reduce or inhibit scarring associated with one form will generally be similarly effective in the other form of scarring

Fibrotic disorders are usually chronic. Examples of fibrotic disorders include cirrhosis of the liver, liver fibrosis, glomerulonephritis, pulmonary fibrosis, chronic obstructive pulmonary disease, scleroderma, myocardial fibrosis, fibrosis following myocardial infarction, proliferative vitreoretinopathy (PVR), arthritis and adhesions e.g. in the digestive tract, abdomen, pelvis, spine.

If not treated, the pathological effects of scarring associated with fibrotic disorders may lead to organ failure, and ultimately to death.

Whilst much of the present specification concentrates primarily on the effects of scarring (whether scarring that results from healing of a wound, or scarring associated with fibrotic disorders) in man, it will be appreciated that many aspects of the scarring response are conserved between most species of animals. Thus, the problems outlined above are also applicable to non-human animals, and particularly veterinary or domestic animals (e.g. horses, cattle, dogs, cats etc). By way of example, it is well known that adhesions resulting from the inappropriate healing of abdominal wounds constitute a major reason for the veterinary destruction of horses (particularly race horses). Similarly the tendons and ligaments of domestic or veterinary animals are also frequently subject to injury, and healing of these injuries may also lead to scarring associated with increased animal mortality.

Although the ill effects of scarring (either resulting from normal or aberrant wound healing, or associated with fibrotic disorders) are well known there remains a lack of effective therapies able to reduce these effects. In the light of this absence it must be recognised that there exists a strongly felt need to provide medicaments and treatments that are able to prevent, reduce or inhibit scar formation, whether resulting from healing of a wound, or associated with fibrotic disorders.

The WNT family of genes (wingless-type MMTV integration site family) encode a number of proteins that function as pleiotropic cell signalling molecules. These proteins, designated WNTs, share a number of conserved residues, including a characteristic cysteine pattern. It is these structural features, rather than shared function, that define the WNT proteins, since the effects of various WNT family members may differ markedly depending on the responding cells.

It is generally believed that Frizzled (Fz) molecules constitute the primary group of receptors for WNT family members. Frizzled receptors comprise seven membrane-spanning portions as well as a long amino terminal region designated the cysteine-rich domain (CRD). The CRD appears to constitute the WNT-binding portion of Fz receptors. Effective WNT signalling requires not only the presence of WNT and a Fz receptor, but also the presence of a protein of the LRP (LDL receptor related protein) class.

WNT3A is a member of the WNT family of signalling molecules. Human WNT3A is a 352 amino acid polypeptide, the sequence of which is shown in Sequence ID No. 1. The human and murine forms of WNT3A share 96% amino acid identity. The sequence of DNA encoding human WNT3A (also designated WNT3A) is set out in Sequence ID No. 2. The amino acid sequence of the murine equivalent (designated Wnt3a) is set out in Sequence ID No. 3, and the sequence of DNA encoding murine Wnt3a is set out in Sequence ID No.4. The amino acid sequence of rat Wnt3a is set out as Sequence ID No. 5, and the sequence of DNA encoding rat Wnt3a is set out in Sequence ID No.6.

Previous reports indicate that WNT3A is able to signal through a number of receptors, or receptor complexes. WNT3A has been shown to interact with LRP5 and LRP6, as well as Frizzled 8 (FZD8). The nucleotide sequence of LRP5 is shown as Sequence ID No. 7, and the amino acid sequence of LRP5 shown as Sequence ID No. 8. The nucleotide sequence of LRP6 is shown as Sequence ID No. 9, and the amino acid sequence of LRP6 shown as Sequence ID No. 10. The nucleotide sequence of FZD8 is shown as Sequence ID No. 11, and the amino acid sequence of FZD8 shown as Sequence ID No. 12.

It is an aim of certain aspects of the present invention to provide medicaments suitable for the prevention and/or reduction and/or inhibition of scarring. It is an aim of further aspects of the present invention to provide methods of treatment suitable for use in the prevention, and/or reduction, and/or inhibition of scarring. It is an aim of certain embodiments of the invention to provide medicaments suitable for the prevention and/or treatment of scarring that results from healing of a wound. It is an aim of certain embodiments of the invention to provide medicaments suitable for the prevention and/or treatment of scarring associated with fibrotic disorders. It is an aim of certain embodiments of the invention to provide methods of treatment suitable for use in the prevention and/or treatment of scarring that results from healing of a wound. It is an aim of further embodiments of the invention to provide methods of treatment suitable for use in the prevention and/or treatment of scarring associated with fibrotic disorders. The medicaments and/or methods of the invention may constitute alternatives to those provided by the prior art. However, it is preferred that medicaments and/or methods of treatment provided by the invention may constitute improvements over the prior art.

According to a first aspect of the present invention there is provided the use of WNT3A, or a therapeutically effective fragment or derivative thereof, in the manufacture of a medicament for the prevention, reduction or inhibition of scarring. This aspect of the invention also provides WNT3A, or a therapeutically effective fragment or derivative thereof, for use as a medicament for the prevention, reduction or inhibition of scarring.

In a second aspect of the invention there is provided a method of preventing, reducing or inhibiting scarring, the method comprising administering a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, to a patient in need of such prevention, reduction or inhibition. The WNT3A, or therapeutically effective fragment or derivative thereof, may preferably be administered to the site where scarring is to be prevented, reduced or inhibited. The site may preferably be a wound, or a site where a wound is to be formed.

It may be preferred that the medicaments or methods of the invention utilise WNT3A itself. It will be appreciated that the WNT3A to be used will generally be human WNT3A, as set out in Sequence ID No. 1.

The scarring, prevention, reduction or inhibition of which is to be achieved by the medicaments or methods of the invention, may be scarring that results from healing of a wound, or, additionally or alternatively, may be scarring associated with a fibrotic disorder. It may be preferred that the scarring is scarring that results from the healing of a wound.

The skin represents a preferred site at which scarring may be prevented, reduced or inhibited utilising the medicaments or methods of the invention. Such scarring of the skin may result from healing of a wound and/or may be associated with a fibrotic disorder. Scarring resulting from the healing of skin wounds represents a form of scarring that may particularly benefit from prevention, reduction or treatment in accordance with the present invention, and with the medicaments or methods of the present invention.

The present invention is based on the inventors' new and surprising finding that WNT3A, or therapeutically effective fragments or derivatives thereof, may be used in the prevention, reduction or inhibition of scarring. There are no previous reports that would lead the skilled person to believe that WNT3A, or its fragments or derivatives, may be used to effectively prevent, reduce or inhibit scarring.

The finding that WNT3A, or fragments or derivatives thereof, may be used to prevent, reduce or inhibit scarring provides the foundation for new medicaments and methods that may be used in the treatment or management of scarring. Furthermore, the inventors' finding that WNT3A, or its fragments or derivatives, may be used in the prevention, reduction or inhibition of scarring offers the prospect that improved medicaments and methods may be made available for the treatment or management of scarring.

The inventors believe that the prevention, reduction or inhibition of scarring using WNT3A, or therapeutically effective fragments or derivatives thereof, can be effected at

any body site and in any tissue or organ. Medicaments and methods of the invention utilising WNT3A, or therapeutically effective fragments or derivatives thereof, may be used in the prevention, reduction or inhibition of scarring that may otherwise result from the healing of a wound. Alternatively, or additionally, medicaments and methods of the invention utilising WNT3A, or therapeutically effective fragments or derivatives thereof, may be used in the prevention, reduction or inhibition of scarring that may otherwise be associated with a fibrotic disorder. It is particularly preferred that medicaments or methods of the invention be used to prevent, reduce or inhibit scarring of the skin, whether such scarring arises as a result of healing of a skin wound, or in association with a fibrotic disorder afflicting the skin.

WNT3A, or a therapeutically effective fragment or derivative thereof, may preferably be administered to a site that may be associated with scarring (for the present purposes a site where scarring has already occurred, or may be expected to occur). For example, WNT3A, or therapeutically effective fragments or derivatives thereof, may be administered to a patient's wound that would otherwise be likely to give rise to a scar.

WNT3A, or a therapeutically effective fragment or derivative thereof, may be administered to an existing scar to prevent the further progression of scarring. Administration of WNT3A, or therapeutically effective fragments or derivatives thereof, to an existing scar may also reduce the level of scarring associated with the existing scar. It will thus be appreciated that WNT3A, or a therapeutically effective fragment or derivative thereof, may be administered to a site of a fibrotic disorder in order to prevent further scarring, and/or to reduce scarring that has already occurred associated with the fibrotic disorder. Preferred routes of administration that may be used in accordance with all of the embodiments considered above include topical administration, and particularly topical injection of suitable active agents.

Examples of specific contexts in which the prevention, reduction or inhibition of scarring that may otherwise arise from the healing of a wound may be achieved using the medicaments and methods of the invention include, but are not limited to, those selected from the group consisting of: use in the skin; use in the eye (including the prevention,

reduction or inhibition of scarring resulting from eye surgery such as LASIK surgery, PRK surgery, or cataract surgery – in which the lens capsule may be subject to scarring); use in capsular contraction (which is common surrounding breast implants); use in blood vessels; use in the central and peripheral nervous system (where prevention, reduction or inhibition of scarring may enhance neuronal reconnection); use in tendons, ligaments or muscle; use in the oral cavity, including the lips and palate (such as in preventing, reducing or inhibiting scarring resulting from treatment of cleft lip or palate); use in the internal organs such as the liver, heart, brain, digestive tissues and reproductive tissues; and use in body cavities such as the abdominal cavity, pelvic cavity and thoracic cavity (where prevention, reduction or inhibition of scarring may reduce the number of incidences of adhesion formation and/or the size of adhesions formed. The medicaments and methods of the invention may be used to prevent, reduce or inhibit adhesions, such as those occurring in the abdomen, pelvis or spine. It is particularly preferred that the medicaments and methods of the invention be used to prevent, reduce or inhibit scarring of the skin (dermal scarring).

Scarring associated with fibrotic disorders that may be prevented, reduced or inhibited using medicaments or methods of the invention may preferably include scarring associated with fibrotic disorders selected from the group consisting of: skin fibrosis; scleroderma; progressive systemic fibrosis; lung fibrosis; muscle fibrosis; kidney fibrosis; glomerulosclerosis; glomerulonephritis; uterine fibrosis; renal fibrosis; cirrhosis of the liver, liver fibrosis; chronic obstructive pulmonary disease; fibrosis following myocardial infarction; central nervous system fibrosis, such as fibrosis following stroke; fibrosis associated with neuro-degenerative disorders such multiple sclerosis; fibrosis associated with proliferative vitreoretinopathy (PVR); restenosis; endometriosis; ischemic disease and radiation fibrosis.

Various terms that are used in the present disclosure to describe the invention will now be explained further. The definitions and guidance provided below may be expanded on elsewhere in the specification as appropriate, and as the context requires.

**"Therapeutically effective amounts"**

A therapeutically effective amount of WNT3A, or a fragment or derivative thereof, is any amount of WNT3A, or a therapeutically effective fragment or derivative thereof, which is able to inhibit scarring. Such scarring may be associated with a wound or a fibrotic disorder.

A therapeutically effective amount of WNT3A, or a fragment or derivative thereof, is preferably an amount of WNT3A, or a fragment or derivative thereof, which is able to inhibit scarring of a wound (or site at which a wound is to be formed) or a fibrotic disorder (or site at which a fibrotic disorder will occur) to which the WNT3A, or fragment or derivative, is administered.

A therapeutically effective amount of a medicament of the invention is any amount of a medicament of the invention that is able to inhibit scarring. This inhibition of scarring may preferably be achieved at a site to which the medicament of the invention is administered.

A therapeutically effective amount of fragment or derivative of WNT3A, or of a medicament of the invention, may preferably be an amount of fragment or derivative that is effective to inhibit scarring by at least 10% compared to a relevant control. Preferably a therapeutically effective amount of WNT3A, or a fragment or derivative of WNT3A, or of a medicament of the invention, may be capable of inhibiting scarring by at least 20%, more preferably at least 50%, even more preferably at least 75% and yet more preferably of inhibiting scarring by at least 90% compared to a relevant control. A most preferred therapeutically effective amount of WNT3A, or a fragment or derivative of WNT3A, or a medicament of the invention, may be capable of inhibiting scarring by 100% as compared to a relevant control.

The selection of a suitable control will be apparent to one skilled in the art, but by way of guidance, in the event that it is wished to assess inhibition of scarring on healing of treated wounds, a suitable control may comprise an untreated or control treated wound.

In the event that it is wished to assess inhibition of scarring achieved by provision of WNT3A, or a therapeutically effective fragment or derivative thereof, to an existing scar, an untreated scar may constitute a suitable control.

Thus a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative of WNT3A, or of a medicament of the invention, may be an amount that is effective to reduce scarring occurring on healing of a treated wound by at least 10% compared to scarring occurring on healing of an untreated or control wound. "Treated wounds" and "untreated wounds" or "control wounds" are defined elsewhere in the specification. Preferably a therapeutically effective amount may be capable of causing a 20% inhibition of scarring, more preferably at least a 50% inhibition, even more preferably at least a 75% inhibition and most preferably at least a 90% inhibition of the scarring occurring on healing of a treated wound as compared to scarring occurring on healing of an untreated or control wound.

In the case of scarring that may otherwise be associated with a fibrotic disorder, a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative of WNT3A, or of a medicament of the invention, may be an amount that is effective to reduce scarring of a treated site of fibrosis by at least 10% compared to the amount scarring that would otherwise be present at a comparable untreated site of fibrosis. A "treated site of fibrosis" and "untreated site of fibrosis" are defined further elsewhere in the specification. Preferably a therapeutically effective amount may be capable of achieving at least a 20% reduction in scarring, more preferably at least 50%, even more preferably at least 75% and most preferably at least a 90% reduction in scarring compared to scarring present at a comparable untreated site of fibrosis.

The skilled person will appreciate that a fragment or derivative of WNT3A that has little inherent therapeutic activity will still be therapeutically effective if administered in a quantity that provides a therapeutically effective amount.

A therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, may preferably be an amount able to therapeutically alter the abundance and/or orientation of ECM components (such as collagen) in a treated scar.

A medicament of the invention should provide a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof. Preferably a medicament of the invention may be provided in the form of one or more dosage units. Each dosage unit may comprise a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, or a known fraction or multiple of such a therapeutically effective amount.

The inventors have surprisingly found that WNT3A, or its therapeutically effective fragments or derivatives, exerts its greatest inhibition of scarring at relatively low doses.

By way of example, the inventors have established that a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, should preferably be less than 24 pmoles per linear cm (or $cm^2$) of a wound, or of a fibrotic disorder, the scarring of which it is wished to inhibit. Preferably, a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, should not exceed 12 pmoles per linear cm (or $cm^2$) of a wound or fibrotic disorder. Preferably a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, may be between 24 fmoles and 2.4 pmoles per linear cm (or $cm^2$) of a wound or fibrotic disorder in which it is wished to inhibit scarring.

By way of further illustration, the provision of approximately 100ng or less of WNT3A per linear cm of wound, or $cm^2$ of a wound or fibrotic disorder, over a 24 hour period will constitute a therapeutically effective amount. More preferably, a therapeutically effective amount of WNT3A should be less than about 50ng per linear cm of wound, or $cm^2$ of a wound or fibrotic disorder, over a 24 hour period, and even more preferably should be approximately 1ng of WNT3A per linear cm of wound, or $cm^2$ of a wound or fibrotic disorder, over a 24 hour period.

Provision of approximately 1ng of WNT3A per linear cm of wound, or $cm^2$ of a wound or fibrotic disorder constitutes a preferred therapeutically effective amount for use in the medicaments or methods of the invention.

Preferred therapeutically effective amounts of WNT3A, or a therapeutically effective fragment or derivative thereof, (either generally, or with reference to specific selected fragments or derivatives) may be investigated using *in vitro* and *in vivo* models, and suitable assessments of efficacy made with reference to various parameters for the measurement of scarring, as described elsewhere in the specification.

**"Therapeutically effective fragments or derivatives of WNT3A"**

For the purpose of the present disclosure, "therapeutically effective fragments or derivatives of WNT3A" should be taken (except for where the context requires otherwise) to encompass any fragment or derivative of WNT3A that is capable of inhibiting scarring. Preferred means by which such inhibition of scarring may be assessed are considered elsewhere in the specification.

Except for where the context requires otherwise, it should be considered that therapeutically effective derivatives may be derived either from WNT3A itself, or from therapeutically effective fragments of WNT3A. Preferred fragments or derivatives of WNT3A for use in the medicaments and methods of the invention may be those based on human WNT3A, the amino acid sequence of which is shown in Sequence ID No. 1.

A therapeutically effective fragment or derivative of WNT3A may be a fragment or derivative that is effective to inhibit scarring by at least 10% compared a suitable control. Preferably a therapeutically effective fragment or derivative of WNT3A may be capable of inhibiting scarring by at least 20%, more preferably at least 50%, even more preferably at least 75% and yet more preferably by at least 90% compared to a suitable control. A most preferred therapeutically effective fragment or derivative of WNT3A may be capable of inhibiting scarring by 100% as compared to a suitable control.

In particular, therapeutically effective fragments or derivatives of WNT3A suitable for use in the medicaments or methods of the invention may be those able to alter the amount and/or orientation of extracellular matrix components (such as collagen) present in a treated scar and thereby inhibit scarring.

Preferably a therapeutically effective fragment or derivative of WNT3A may be one that is capable of inhibiting scarring at a site to which the fragment or derivative of WNT3A is administered. Such a site may be a wound, or scar resulting from the healing of a wound. Alternatively or additionally, such a site may be a site of a fibrotic disorder.

Suitable therapeutically effective amounts of WNT3A, as well as suitable therapeutically effective fragments or derivatives of WNT3A, are considered elsewhere in the specification.

Preferably a therapeutically effective fragment or derivative of WNT3A suitable for use in accordance with the present invention may be one that is capable of preventing, reducing or inhibiting scarring that may otherwise result from a wound. Preferred therapeutically effective fragments or derivatives of WNT3A may be capable of preventing, reducing or inhibiting scarring of a wound (or site where a wound is to be formed) to which they are added. Additionally, or alternatively, a therapeutically effective fragment or derivative of WNT3A suitable for use in accordance with the present invention may be one capable of preventing, reducing or inhibiting scarring associated with a fibrotic disorder. Such a therapeutically effective fragment or derivative of WNT3A may be capable of preventing, reducing or inhibiting scarring associated with a fibrotic disorder at a site where the fragment or derivative is added.

**"Therapeutically effective fragments"**

Therapeutically effective fragments of WNT3A suitable for use in accordance with the present invention may comprise 25 or more amino acid residues from Sequence ID No. 1, preferably up to 100 amino acid residues, more preferably up to 200 amino acid residues, and even more preferably up to 300 amino acid residues. Fragments suitable for use in

the medicaments and methods of the present invention include those comprising up to 350 amino acids residues of Sequence ID No. 1. Preferred fragments will comprise at least 25 amino acid residues from Sequence ID No. 1.

Therapeutically effective fragments of WNT3A suitable for use in accordance with the present invention may comprise up to 10 contiguous amino acid residues from Sequence ID No. 1, preferably up to 100 contiguous amino acid residues, more preferably up to 200 contiguous amino acid residues, and even more preferably up to 300 contiguous amino acid residues. Fragments suitable for use in the medicaments and methods of the present invention include those comprising up to 350 amino acids residues of Sequence ID No. 1. Preferred fragments will comprise at least 10 contiguous amino acid residues from Sequence ID No. 1.

Therapeutically effective fragments of WNT3A suitable for use in accordance with the present invention may comprise at least 10 contiguous amino acid residues from Sequence ID No. 1, preferably at least 100 contiguous amino acid residues, more preferably at least 200 contiguous amino acid residues, and even more preferably at least 300 contiguous amino acid residues. Fragments suitable for use in the medicaments and methods of the present invention include those comprising at least 350 amino acids residues of Sequence ID No. 1.

WNT proteins are generally palmitoylated on a cysteine residue. Studies in which palmitoylation of WNTs has been disrupted by acyl protein thioesterase indicate that the presence of palmitate is essential in order for WNTs to exert their biological activity.

The inventors believe that WNT3A is palmitoylated on the cysteine residue located at position 77 in the amino acid sequence shown in Sequence ID No. 1. Accordingly, it is preferred that fragments of WNT3A for use in accordance with the invention should be fragments that comprise the cysteine residue located at position 77 of Sequence ID No. 1 (the skilled person will readily appreciate that the numbered position of this cysteine residue, referred to as cysteine 77, may change within a particular fragment depending on

the length of the fragment in question). Preferred fragments of WNT3A may be palmitoylated fragments, and particularly those palmitoylated at cysteine 77.

Preferred fragments may include amino acid residues involved in binding of WNT3A to its cellular receptors. Previous reports indicate that WNT3A is able to signal through a number of receptors, or receptor complexes. WNT3A has been shown to interact with both LRP5 and LRP6 as well as FZD8.

Preferred therapeutically effective fragments or derivatives of WNT3A will be those that incorporate a receptor-binding region of WNT3A (either in whole or in part). It will be appreciated that it is the three dimensional structure of WNT3A that is important in considering receptor binding, and that accordingly suitable fragments may be selected based upon their ability to assume the requisite three dimensional conformation necessary for receptor binding.

**"Therapeutically effective derivatives"**

Although peptides comprising all or part of WNT3A (as defined by Sequence ID No. 1) represent preferred agents for use in accordance with the present invention, it will be recognised that there are contexts in which the sensitivity of peptides to degradation may be disadvantageous. There are many known techniques by which peptide derivatives may be produced that have greater resistance to degradation than do the original peptides from which they are derived.

Peptoid derivatives may be expected to have greater resistance to degradation than do peptide agents of the invention, whilst retaining the same ability to inhibit scarring. Suitable peptoid derivatives may be readily designed from knowledge of WNT3A's sequence and structure. Commercially available software may be used to develop suitable peptoid derivatives according to well-established protocols. It will be appreciated that the therapeutic effectiveness of peptoid and other derivatives may be investigated using any suitable technique (illustrative examples of which are described elsewhere in the specification).

Retropeptoids based on WNT3A or its therapeutically effective fragments (but in which all amino acids are replaced by peptoid residues in reversed order) are also able to inhibit scarring. A retropeptoid may be expected to bind in the opposite direction in the ligand-binding groove, as compared to a peptide or peptoid-peptide hybrid containing one peptoid residue. As a result, the side chains of the peptoid residues are able to point in the same direction as the side chains in the original peptide.

D-amino acid forms of WNT3A or its therapeutically effective fragments also confer the requisite ability to inhibit scarring. In the case of D-amino acid forms, the order of the amino acid residues comprising the derivative is reversed as compared to those in the original peptide. The preparation of derivatives using D-amino acids rather than L-amino acids greatly decreases any unwanted breakdown of such an agent by normal metabolic processes, decreasing the amounts of agent which need to be administered, along with the frequency of its administration.

It will be appreciated that derivatives suitable for use in the medicaments and methods of the invention clearly include both those derived from full length WNT3A and those derived from therapeutically effective fragments of WNT3A (as considered elsewhere in the specification).

A therapeutically effective derivative of WNT3A suitable for use in accordance with the present invention may share at least 10% homology with Sequence ID No. 1, preferably at least 25% homology, more preferably at least 50% homology, and even more preferably at least 75% homology. Particularly preferred derivatives may share at least 80%, 85%, 90%, 95% or greater homology with Sequence ID No. 1.

Therapeutically effective derivatives of WNT3A suitable for use in accordance with the present invention may share at least 10% identity with Sequence ID No. 1, preferably at least 25% identity, more preferably at least 50% identity, and even more preferably at least 75% identity. Particularly preferred derivatives may share at least 80%, 85%, 90%, 95% or greater identity with Sequence ID No. 1.

Suitable means by which homology or identity values may be determined will be apparent to those skilled in the art.

**"Active agents"**

An "active agent", for the purposes of the present disclosure, should be taken to be WNT3A, or any therapeutically effective fragment or derivative thereof.

The skilled person will appreciate that a mixture of two, or more, different active agents may be used in the medicaments or methods of the invention to inhibit scarring. Indeed, such use may represent a preferred embodiment of the invention.

WNT3A, or therapeutically effective fragments or derivatives thereof suitable for use in accordance with the present invention, should preferably be taken to exclude members of the WNT family other than WNT3A.

The skilled person will appreciate that many of the active agents suitable for use in the medicaments or methods of the present invention are suitable for cellular expression at a site where scarring is to be inhibited (or at a site from where their product may be available to a site where scarring is to be inhibited). This method of action may be termed "gene therapy", and is described in greater detail elsewhere in the specification. In light of the above it will be appreciated that the cellular expression of a therapeutically effective amount of WNT3A, or a fragment or derivative thereof, at a site where scarring is to be inhibited represents a preferred embodiment of the invention. Such expression may preferably be transient, and may finish once a desired inhibition of scarring has been effected. Nucleic acid constructs encoding WNT3A, or a therapeutically effective fragment or derivative thereof, may be used in the medicaments or methods of the invention.

**"Medicaments of the invention"**

For the purposes of the present disclosure, medicaments of the invention should be taken as encompassing any medicament manufactured in accordance with any aspect or embodiment of the invention.

Medicaments of the invention will generally comprise a pharmaceutically acceptable excipient, diluent or carrier in addition to the WNT3A, or therapeutically effective fragment or derivative thereof. Medicaments of the invention may preferably be in the form of an injectable solution comprising WNT3A, or a therapeutically effective fragment or derivative thereof. Solutions suitable for localised injection (such as intradermal injection) constitute particularly preferred forms of the medicaments of the invention.

**Preferred sites, conditions and disorders for treatment in accordance with the invention**

The inhibition of scarring that may be achieved utilising therapeutically effective amounts of WNT3A, or its fragments or derivatives, may be of benefit in almost all circumstances where unwanted scarring would otherwise occur.

The following paragraphs are in no way intended to limit the uses to which methods and medicaments of the invention may be put, but may provide useful guidance as to contexts in which it may be wished to inhibit scarring by use of a therapeutically effective amount of WNT3A, or a fragment or derivative thereof.

The use of methods and medicaments of the invention to inhibit scarring may bring about a notable improvement in the cosmetic appearance of an injured area thus treated. Cosmetic considerations are important in a number of clinical contexts, particularly when scars may be formed at prominent body sites such as the face, neck and hands. Consequently it is a further preferred embodiment that the medicaments and methods of the invention be used to inhibit scarring at sites where it is desired to improve the cosmetic appearance of a scar formed. Indeed, it is a preferred embodiment that the

medicaments and methods of the invention be used to inhibit scarring associated with cosmetic surgery. Since the great majority of cosmetic surgeries consist of elective surgical procedures it is readily possible to administer a therapeutically effective amount of WNT3A, or a fragment or derivative thereof, prior to surgery, and/or immediately following closure of the wound (e.g. with sutures), and this use represents a particularly preferred embodiment of the invention. In the case of elective surgical procedures a preferred route by which WNT3A, or a therapeutically effective fragment or derivative thereof, may be administered is via intradermal injection. Such injections may form raised blebs, and these may be formed at the site where the wound is to be formed (in which case they may then be incised as part of the surgical procedure), or along the margins of the wound to be formed. Alternatively a bleb may be raised by injecting the wound margins after the wound has been formed and/or closed (e.g. by sutures).

The cosmetic outcome of surgical procedures is also an important consideration in plastic surgery, and the use of methods or medicaments of the invention to inhibit scarring associated with plastic surgery constitutes a further preferred embodiment of the invention.

In addition to its cosmetic impact, scarring of the skin is responsible for a number of deleterious effects afflicting those suffering from such scarring. For example, scarring of the skin may be associated with reduction of physical and mechanical function, particularly in the case of contractile scars (such as hypertrophic scars) and/or situations in which scars are formed across joints (articulations). The contraction exhibited by contractile scars of this kind is more pronounced than wound contraction that occurs as a normal part of the healing process, and may be distinguished from such normally occurring contraction in that it continues long after the healing process has ended (i.e. after wound closure). In cases of scars located in the area of joints the altered mechanical properties of scarred skin, as opposed to unscarred skin, and the effects of scar contraction may lead to dramatically restricted movement of a joint so effected. Accordingly, it is a preferred embodiment that suitable medicaments and methods of the invention be used to inhibit scarring covering joints of the body (whether such scars result from the healing of wounds covering the joint, or are associated with fibrotic disorders covering the joint). In

another preferred embodiment suitable medicaments and methods of the invention may be used to inhibit scarring at increased risk of forming a contractile scar (in the case of scarring that results from the healing of wounds this may include wounds of children, and/or wounds produced by burns).

It is recognised that wounds resulting from burns injuries (which for the purposes of the present invention may be taken to encompass scalding injuries involving hot liquids or gasses) may extend over great areas of an individual so afflicted. Accordingly, burns may give rise to scar formation covering a large proportion of a patient's body. This great extent of coverage increases the risk that the scar formed will cover areas of elevated cosmetic importance (such as the face, neck, arms or hands) or of mechanical importance (particularly the regions covering or surrounding joints). Burns injuries caused by hot liquids are frequently suffered by children (for example as a result of upsetting pans, kettles or the like) and, due to the relatively smaller body size of children, are particularly likely to cause extensive damage over a high proportion of the body area. Furthermore, burns injuries, and particularly those suffered by children, have an elevated risk of producing pathological hypertrophic scars of the type described below. Such hypertrophic scars may increase both the cosmetic and mechanical impairment associated with scarring after burns. It is a preferred embodiment that medicaments and methods of the invention be used to inhibit scarring resulting from burns injuries.

The extent of scar formation, and hence extent of cosmetic or other impairment that may be caused by the scar, may also be influenced by factors such as the tension of the site at which the scar is formed (and in the case of scarring that results from the healing of a wound, the tension at the site where the wound is formed). For example, it is known that skin under relatively high tension (such as that extending over the chest, or associated with lines of tension) may be prone to formation of more severe scars than at other body sites. Thus in a preferred embodiment suitable medicaments and methods of the invention may be used to inhibit scarring at sites of high skin tension (for example, scarring occurring as a result of wounds at such sites).

There are many surgical procedures that may be used in scar revision to allow realignment of wounds and scars such that they are subject to reduced tension. Probably the best known of these is "Z-plasty" in which two V-shaped flaps of skin are transposed to allow rotation of a line of tension. In a more preferred embodiment the medicaments and methods of the invention may be used to inhibit scarring of wounds during surgical revision of scars.

Pathological scarring may have more pronounced deleterious effects than arise even as a result of relatively severe normal scarring. Common examples of pathological scars include keloids, hypertrophic scars and pterygium.

Keloid scars (or keloids) constitute a notable example of pathological scarring, and are raised scars that spread beyond the margins of the original wound and invade the surrounding normal skin. Keloids continue to grow over time, do not regress spontaneously, and frequently recur following surgical excision. Keloid scars occur with equal frequency in men and women, mainly from ages 10 to 30, and can result from piercing, surgery, vaccination, tattoos, bites, blunt trauma and burns. A number of studies have suggested that there is an underlying genetic predisposition to keloid formation since keloid scars are more prevalent in dark skinned races, and in individuals of the African Continental Ancestry Group or Asian Continental Ancestry Group.

Keloids appear as elevated scars that may typically be hyperpigmented or hypopigmented in relation to the surrounding skin. Keloids may be characterised on the basis of their tendency to grow beyond the initial boundaries of the wound from which they result. At a microscopic level, keloids may be characterised by the presence of large whorls of collagen, and the predominantly acellular nature of the interior of the lesion.

Hypertrophic scars are raised scars which may have an appearance very similar to keloid lesions. Unlike keloids, hypertrophic scars do not expand beyond the boundaries of the original injury and are not prone to recurrence after excision. Hypertrophic scars may frequently undergo contraction, and it is believed that the contractile nature of hypertrophic scars may be associated with the elevated numbers of myofibroblasts that

are frequently reported within these types of scars. Hypertrophic scars may commonly arise as a result of burn or scald injuries, and are particularly common amongst children.

Pterygium is a hypertrophied outgrowth of the subconjunctival tissue to the border of the cornea or beyond. The outgrowth is typically triangular in shape, with the apex pointing towards the pupil. Pterygium may interfere with vision, and may require surgery to remove the hypertrophied tissue. Furthermore, the tissue may frequently re-grow after excision, in the same manner as keloid scars, thus requiring multiple incidences of surgery.

It is recognised that certain types of wound, or certain individuals may be predisposed to pathological scar formation. For instance individuals of the African Continental Ancestry Group or Asian Continental Ancestry Group, or those having a familial history of pathological scarring may be considered to be at increased risk of hypertrophic scar or keloid formation. Wounds of children, and particularly burns wounds of children, are also associated with increased hypertrophic scar formation. Incidences of pterygium may be increased amongst those in whom the eye is frequently exposed to intense sunlight or dust. Accordingly it is a preferred embodiment of the invention that suitable medicaments and methods be used to inhibit scarring of wounds in which there is an increased risk of pathological scar formation.

Although individuals already subject to pathological scarring may suffer from a predisposition to further excessive scar formation, it is often clinically necessary to surgically revise hypertrophic scars or keloids, with an attendant risk of consequential pathological scar formation. Thus, it is a further preferred embodiment of the invention that the medicaments or methods herein described be used to inhibit scarring that results from wounds produced by surgical revision of pathological scars.

The ability of WNT3A, or therapeutically effective fragments or derivatives thereof, to inhibit scarring is of great utility in the inhibition of scarring associated with grafting procedures. In particular, the medicaments and methods of the invention may be used to inhibit scarring that results from wounds associated with grafting procedures. Inhibition of

scarring using the medicaments and methods of the invention is of benefit both at a graft donor sites and graft recipient sites. The scar inhibitory effects of the medicaments and methods of the invention are able to inhibit scarring that may otherwise occur at sites where tissue for grafting is removed, or that may be associated with the healing and integration of grafted tissue. The inventors believe that the methods and medicaments of the invention confer advantages in the inhibition of scarring that may otherwise be associated with grafts utilising skin, artificial skin, or skin substitutes.

The inventors also believe that the medicaments and methods of the invention may be used to inhibit scarring associated with encapsulation. Encapsulation is a form of scarring that occurs around sites at which implant materials (such as biomaterials) have been introduced into the body. Encapsulation is a frequent complication associated with breast implants, and the use of the medicaments or methods of the invention to inhibit encapsulation in this context is a preferred embodiment of the invention.

The medicaments and methods of the invention may be used to inhibit scarring that results from a wide range of wound types, which may occur at a wide range of body sites. The medicaments and methods of the invention may be used to inhibit scarring that results from healing of wounds selected from the group consisting of: abrasions; avulsions; crush wounds; incisional wounds; lacerations; punctures; and missile wounds. All of these different types of wounds may be suffered by the skin, among other tissues or organs, and all may, to a greater or lesser extent, result in scarring.

Incisional wounds are also commonly referred to as “cuts”. Incisional wounds result from incision, or slicing, of a tissue with a sharp instrument, which results in a wound with relatively even edges. Incisional wounds can vary greatly in their severity, from minimal wounds (such as a paper cut) to significant wounds such as those arising as a result of surgical incision. An incisional wound may have little or profuse bleeding depending on the depth and length of the wound, and also on the tissue involved. The even edges of incisional wounds will generally readily line up, which may facilitate closure of such wounds. Incisional wounds are a frequent cause of scarring, and it will be appreciated that the

medicaments and methods of the invention may advantageously be used in the inhibition of scarring resulting from incisional wounds.

Incisional wounds constitute preferred wounds scarring resulting from which may be inhibited by the medicaments and methods of the invention. Surgical incisional wounds may constitute a particularly preferred group of wounds in respect of which scarring may be inhibited utilising the medicaments and methods of the invention.

It will be appreciated that tissues other than the skin, such as the cornea, may also be subject to wounds of the type described above and elsewhere in the specification. The medicaments and methods of the invention may also be of benefit in inhibiting scarring associated with such wounds in these tissues.

The healing of wounds involving the peritoneum (the epithelial covering of the internal organs, and/or the interior of the body cavity) may frequently give rise to adhesions. Such adhesions are formed by bands of fibrous scar tissue, and can connect the loops of the intestines to each other, or the intestines to other abdominal organs, or the intestines to the abdominal wall. Adhesions can pull sections of the intestines out of place and may block passage of food. Adhesions are also a common sequitur of surgery involving gynaecological tissues. Incidences of adhesion formation may be increased in wounds that are subject to infection (such as bacterial infection) or exposure to radiation.

The inventors believe that the ability of the medicaments and methods of the invention to inhibit scarring may reduce the occurrence of adhesions. Accordingly, the use of medicaments or methods of the invention to prevent the formation of intestinal or gynaecological adhesions represents a preferred embodiment of the invention. The medicaments and methods of the invention may also be useful in the inhibition of scarring, including formation of adhesions, that may occur on healing of infected wounds or wounds exposed to radiation. Indeed, the skilled person will appreciate that the use of medicaments or methods of the invention in the inhibition of any scarring involving the peritoneum is a preferred embodiment. Medicaments for this purpose may be

administered by lavage, or in a parenteral gel/instillate or locally e.g. from films or carriers inserted at the time of surgery.

The medicaments or methods of the invention are suitable for use in the inhibition of scarring in the eye, and their use in this context represents a preferred embodiment of the invention. The inventors believe that the medicaments or methods of the invention may be used to inhibit scarring that results from healing of wounds to the eye, and/or to inhibit scarring associated with fibrotic disorders of the eye. Merely by way of example, the medicaments or methods of the invention may be used to inhibit scarring associated with glaucoma filtration surgery, or cataract surgery (where scarring may frequently be associated with contraction of the lens capsule)

In the case of corneal scarring, application of the medicament may be by means of local eye drops, sponge applicator, or the like. Corneal scars may result from the healing of corneal wounds such as those produced by LASIK or PRK procedures. Corneal scarring may be assessed by measuring the opacity, or transmitting/refractory properties, of the cornea. Such assessments may, for example, be made using *in vivo* confocal microscopy.

Scarring elsewhere in the eye, such as at sites of pressure relieving blebs formed in glaucoma surgery, or scarring of the retina associated with proliferative vitreoretinopathy may also be inhibited by the medicaments and methods of the present invention. A therapeutically effective amount of WNT3A, or a fragment or derivative thereof, may be delivered locally, for example by means of a device implanted in the eye, or by injection.

Scarring in the central and peripheral nervous system may be inhibited using the medicaments of the invention. Such scarring may arise as a result of surgery or trauma and may additionally be assessed by future assays of nerve function e.g. sensory or motor tests. The inventors believe that the medicaments or methods of the invention may be useful in improving such future outcomes.

Scarring in the blood vessels e.g. following anastomotic surgery, can lead to myointimal hyperplasia and reduction in the volume of the blood vessel lumen (restenosis). This can

be measured directly e.g. using ultrasound, or indirectly by means of blood flow. Inhibition of scarring achieved using the medicaments or methods of the invention may lead to a reduction in narrowing of the blood vessel lumen and allow a more normal blood flow. A therapeutically effective amount of WNT3A, or a therapeutically fragment or derivative thereof, may be provided to blood vessels by any suitable means. Merely by way of example, these may include direct injection into the walls of the blood vessel before suturing, bathing an anastomotic site in a medium comprising the WNT3A, fragment or derivative, or administration of the active agent by local applied devices, e.g. stents. Effective inhibition of scarring in blood vessels may be indicated by the maintenance of a normal level of blood flow following blood vessel injury.

The medicaments or methods of the invention may be used to inhibit scarring in tendons and ligaments. Such scarring may otherwise be expected to occur following surgery or trauma involving tissues of this type. Successful inhibition of scarring may be indicated by restoration of function of tissues treated with the medicaments or methods of the invention. Suitable indicia of function may include the ability of the tendon or ligament to bear weight, stretch, flex, etc.

**"Treated wounds", "untreated wounds", "treated sites of fibrosis", "untreated sites of fibrosis", "treated scars" and "untreated scars"**

Treatment of wounds with a therapeutically effective amount of WNT3A, or of a fragment or derivative thereof, is able to inhibit the scarring that may otherwise be expected to occur on healing of untreated wounds. The inventors believe that treatment in this manner may have an impact on the macroscopic and/or microscopic appearance of scars formed on the healing of such treated wounds; macroscopically the scars may be less noticeable and blend better with the surrounding normal tissue, microscopically the scars may exhibit an internal structure more akin to that found in normal unwounded tissue. For example, in the case of scars that result from the healing of skin wounds, a treated scar may, when viewed microscopically, exhibit an abundance and orientation of ECM molecules such as collagen that is more similar to that found in normal skin than that found in untreated scars.

For present purposes an "untreated wound" should be considered to be any wound that has not been exposed to a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof. A "diluent control-treated wound" will be an untreated wound to which a control diluent has been administered, and a "naïve control" will be an untreated wound made without administration of WNT3A, or a therapeutically effective fragment or derivative thereof, and without a suitable control diluent, and left to heal without therapeutic intervention.

In contrast, a "treated wound" may be considered to be a wound exposed to a therapeutically effective amount of WNT3A, or a fragment or derivative thereof. Thus a treated wound may be a wound which has been provided with a medicament of the invention, or which has received treatment in accordance with the methods of the invention.

Alternatively, or additionally, treatment of a site of a fibrotic disorder with a therapeutically effective amount of WNT3A, or of a fragment or derivative thereof, is able to inhibit scarring at such a "treated site of fibrosis". This scarring may be compared with that occurring in an untreated or control site of a fibrotic disorder (a site which has not been provided with a therapeutically effective amount of WNT3A, or a fragment or derivative).

The inventors believe that treatment of fibrotic disorders in this manner may have an impact on the macroscopic and/or microscopic appearance of scars associated with fibrotic disorders, such that the macroscopic and/or microscopic structure of a scar at a treated site of fibrosis will be more akin to that found in normal non-fibrotic tissue. For example, in the case of fibrosis involving the skin, a treated scar may, when viewed microscopically, exhibit an abundance and orientation of ECM molecules, such as collagen, that is more similar to that found in normal skin than that found in untreated scars.

For the present purposes a "treated scar" should be taken to encompass:

i) a scar that results from healing of a treated wound (i.e. a wound treated with a therapeutically effective amount of WNT3A, or a fragment or derivative thereof); and/or

ii) a scar produced at a site of a fibrotic disorder that has been treated with a therapeutically effective amount of WNT3A, or a fragment or derivative thereof; and/or

iii) a scar to which a therapeutically effective amount of WNT3A, or a fragment or derivative thereof, has been administered.

By way of contrast, an "untreated scar" should be taken to encompass:

i) a scar that results from healing of an untreated wound (for example a wound treated with a placebo, control, or standard care); and/or

ii) a scar to which a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, has not been administered.

Untreated scars may typically be used as comparators in assessing the inhibition of scarring that may be evident in a treated scar. Suitable comparator untreated scars of this type may preferably be matched to the treated scar with reference to one or more criteria selected from the group consisting of: scar age; scar size; scar site; patient age; patient race and patient gender.

**Models of scarring**

In the case of inhibition of scarring that results from the healing of a wound, a suitable animal model in which the therapeutic effectiveness of WNT3A, or a fragment or derivative thereof, may be assessed, and in which a therapeutically effective amount of an active agent may be determined, may involve providing the WNT3A, or fragment or derivative thereof, to incisional or excisional wounds of experimental animals (such as mice, rats or pigs), and assessing the scarring that results on healing of the wound.

In the case of inhibition of scarring associated with fibrotic disorders, the commonality of the biological mechanisms underlying scarring means that this scarring may also be investigated using incisional or excisional wound healing models of the type outlined above.

However, the skilled person will also be aware of specific models of fibrotic disorders that may be used to further investigate the therapeutic effectiveness of WNT3A, or therapeutically effective fragments or derivatives thereof, in this context. For example, administration of bleomycin to experimental animals allows the generation of an experimental model of fibrosis of the lung that may be used to assess effectiveness of WNT3A, or a fragment or derivative thereof, in the context of inhibiting scarring associated with lung fibrosis. The administration of $CCl_4$ to experimental animals allows the generation of an experimental model of fibrosis of the liver that may be used to assess effectiveness of WNT3A, or a fragment or derivative thereof, in the context of inhibiting scarring associated with liver fibrosis. Furthermore, an experimental model of glomerulonephritis may be established either by injection of suitable serum proteins into an experimental animal or injection of nephrotoxic serum, and either of these animal models may be useful in assessment of WNT3A, or fragments or derivatives thereof, in the inhibition of scarring associated with kidney fibrosis.

**Assessment of scarring, and of inhibition of scarring**

The prevention, reduction or inhibition of scarring within the context of the present invention should be understood to encompass any degree of prevention, reduction or inhibition in scarring achieved on healing of a treated wound, or in a treated scar or treated site of fibrosis as compared to the level of scarring occurring on healing of a control-treated or untreated wound, or in an untreated scar, or at an untreated site of a fibrotic disease. Throughout the specification references to "prevention", "reduction" or "inhibition" of scarring are generally to be taken, except where the context requires otherwise, to represent effectively equivalent activities, involving equivalent mechanisms mediated by WNT3A, or its therapeutically effective fragments or derivatives, and that are all manifested in anti-scarring activity.

For the sake of brevity, the present specification will primarily refer to "inhibition" of scarring utilising WNT3A, or therapeutically effective fragments or derivatives thereof. However, references should be taken, except where the context requires otherwise, to also encompass the prevention or reduction of scarring utilising such active agents. Similarly, references to "prevention" of scarring using WNT3A, or its therapeutically effective fragments or derivatives should, except where the context requires otherwise, be taken also to encompass the treatment of scarring using such active agents.

The extent of inhibition of scarring that may be required in order to achieve a therapeutic effect will be apparent to, and may readily be determined by, a clinician responsible for the care of the patient. The clinician may undertake a suitable determination of the extent of inhibition of scarring that has been achieved using WNT3A, or a therapeutically effective fragment or derivative thereof, in order to assess whether or not a therapeutic effect has been achieved, or is being achieved. Such an assessment may, but need not necessarily, be made with reference to suggested methods of measurement described herein.

The extent to which inhibition of scarring utilising WNT3A, or a therapeutically effective fragment or derivative thereof is achieved may be assessed with reference to the effects that such an active agent may achieve in human patients treated with the methods or medicaments of the invention. Alternatively, inhibition of scarring that may be achieved by WNT3A, or a therapeutically effective fragment or derivative thereof, may be assessed with reference to experimental investigations using suitable *in vitro* or *in vivo* models. The use of experimental models to investigate inhibition of scarring may be particularly preferred in assessing the therapeutic effectiveness of particular fragments or derivatives of WNT3A, or in establishing therapeutically effective amounts of such fragments or derivatives.

Animal models of scarring represent preferred experimental models for *in vivo* assessment of the extent of scar inhibition that may be achieved using the medicaments or methods of the invention. Suitable models may be used specifically to investigate scarring that results from healing of a wound, and, additionally or alternatively, to investigate scarring

associated with fibrotic disorders. Suitable models of both types will be known to those skilled in the art. Examples of such models are described below for illustrative purposes.

The models of scarring and methods for assessing scarring described herein may be used to determine therapeutically effective fragments or derivatives of WNT3A, and therapeutically effective amounts of such fragments or derivatives.

Inhibition of scarring, using the medicaments and methods of the invention, can be effected at any body site and in any tissue or organ so far investigated. For illustrative purposes the scar inhibitory activity of medicaments and methods of the invention will primarily be described with reference to inhibition of scarring that may be brought about in the skin (the body's largest organ). However, the skilled person will immediately appreciate that many of the factors that are relevant when considering inhibition of scarring in the skin are also relevant to inhibition of scarring in other organs or tissues. Accordingly the skilled person will recognise that, except for where the context requires otherwise, the parameters and assessments considered below in respect of scars of the skin may also be applicable to scarring in tissues other than the skin.

In the skin, treatment may improve the macroscopic and microscopic appearance of scars; macroscopically the scars may be less visible and blend with the surrounding skin, microscopically the collagen fibres within the scar may have morphology and organisation that is more similar to those in the surrounding skin.

The inhibition of scarring achieved using methods and medicaments of the invention may be assessed and/or measured with reference to either the microscopic or macroscopic appearance of a treated scar as compared to the appearance of an untreated scar. Inhibition of scarring may also suitably be assessed with reference to both macroscopic and microscopic appearance of a treated scar.

In considering the macroscopic appearance of a scar resulting from a treated wound, the extent of scarring, and hence the magnitude of any inhibition of scarring achieved, may be assessed with reference to any of a number of parameters. Most preferably, holistic

assessment of the scar by means of assessment of macroscopic photographs by an independent expert panel, by means of an independent lay panel or clinically by means of a macroscopic assessment by a clinician of the patients themselves. Assessments are captured by means of a VAS (visual analogue scale) or a categorical scale.

Macroscopic characteristics of a scar which can be assessed objectively include:

i) Colour of the scar. Scars may typically be hypopigmented or hyperpigmented with regard to the surrounding skin. Inhibition of scarring may be demonstrated when the pigmentation of a treated scar more closely approximates that of unscarred skin than does the pigmentation of an untreated scar. Similarly, scars may be redder than the surrounding skin. In this case inhibition of scarring may be demonstrated when the redness of a treated scar fades earlier, or more completely, or to resemble more closely the appearance of the surrounding skin, compared to an untreated scar. There are a number of non-invasive colorimetric devices which are able to provide data with respect to pigmentation of scars and unscarred skin, as well as redness of the skin (which may be an indicator of the degree of vascularity present in the scar or skin). Examples of such devices include the X-rite SP-62 spectrophotometer, Minolta Chronometer CR-200/300; Labscan 600; Dr. Lange Micro Colour; Derma Spectrometer; laser-Doppler flow meter; and Spectrophotometric intracutaneous Analysis (SIA) scope.

ii) Height of the scar. Scars may typically be either raised or depressed as compared to the surrounding skin. Inhibition of scarring may be demonstrated when the height of a treated scar more closely approximates that of unscarred skin (i.e. is neither raised nor depressed) than does the height of an untreated scar. Height of the scar can be measured directly on a patient by means of profilometry, or indirectly, by profilometry of moulds taken from a scar.

iii) Surface texture of the scar. Scars may have surfaces that are relatively smoother than the surrounding skin (giving rise to a scar with a “shiny” appearance) or that are rougher than the surrounding skin. Inhibition of scarring may be demonstrated when the surface texture of a treated scar more

closely approximates that of unscarred skin than does the surface texture of an untreated scar. Surface texture can be measured directly on a patient by means of profilometry, or indirectly by profilometry of moulds taken from a scar.

iv) Stiffness of the scar. The abnormal composition and structure of scars means that they are normally stiffer than the undamaged skin surrounding the scar. In this case, inhibition of scarring may be demonstrated when the stiffness of a treated scar more closely approximates that of unscarred skin than does the stiffness of an untreated scar.

A treated scar will preferably exhibit inhibition of scarring as assessed with reference to at least one of the parameters for macroscopic assessment set out in the present specification. More preferably a treated scar may demonstrate inhibited scarring with reference to at least two parameters, even more preferably at least three parameters, and most preferably at least four of these parameters (for example, all four of the parameters set out above). The parameters described above may be used in the development of a visual analogue scale (VAS) for the macroscopic assessment of scarring. Details regarding implementation of VASs are described below.

Microscopic assessment may also provide a suitable means by which the quality of treated and untreated or control scars may be compared. Microscopic assessment of scar quality may typically be carried out using histological sections of scars. Suitable parameters for the microscopic assessment of scars may include:

i) Thickness of extracellular matrix (ECM) fibres. Scars typically contain thinner ECM fibres than are found in the surrounding skin. This property is even more pronounced in the case of keloid and hypertrophic scars. Inhibition of scarring may be demonstrated when the thickness of ECM fibres in a treated scar more closely approximates the thickness of ECM fibres found in unscarred skin than does the thickness of fibres found in an untreated scar.

ii) Orientation of ECM fibres. ECM fibres found in scars tend to exhibit a greater degree of alignment with one another than do those found in unscarred skin (which have a random orientation frequently referred to as “basket weave”). The

ECM of pathological scars such as keloids and hypertrophic scars may exhibit even more anomalous orientations, frequently forming large "swirls" or "capsules" of ECM molecules. Accordingly, inhibition of scarring may be demonstrated when the orientation of ECM fibres in a treated scar more closely approximates the orientation of ECM fibres found in unscarred skin than does the orientation of such fibres found in an untreated scar.

iii) ECM composition of the scar. The composition of ECM molecules present in scars shows differences from that found in normal skin, with a reduction in the amount of elastin present in ECM of scars. Thus inhibition of scarring may be demonstrated when the composition of ECM fibres in the dermis of a treated scar more closely approximates the composition of such fibres found in unscarred skin than does the composition found in an untreated scar.

iv) Cellularity of the scar. Scars tend to contain relatively fewer cells than does unscarred skin. It will therefore be appreciated that inhibition of scarring may be demonstrated when the cellularity of a treated scar more closely approximates the cellularity of unscarred skin than does the cellularity of an untreated scar.

Other features that may be taken into account in assessing the microscopic quality of scars include elevation or depression of the scar relative to the surrounding unscarred skin, and the prominence or visibility of the scar at the interface with the unscarred skin

The parameters described above may be used in generating a VAS for the microscopic assessment of scarring. Such a VAS may consider collagen organisation and abundance in the papillary dermis and the reticular dermis may also provide a useful index of scar quality. Inhibition of scarring may be indicated when the quality of a treated scar is closer to that of unscarred skin than is the quality of an untreated or control scar.

It is surprising to note that the overall appearance of scars, such as those of the skin, is little influenced by the epidermal covering of the scar, even though this is the part of the scar that is seen by the observer. Instead, the inventors find that the properties of the connective tissue (such as that making up the dermis, or neo-dermis) present within the scar have greater impact on the perception of extent of scarring, as well as on the function

of the scarred tissue. Accordingly assessments of criteria associated with the connective tissues such as the dermis, rather than epidermis, may prove to be the most useful in determining inhibition of scarring.

The thickness of ECM fibres and orientation of ECM fibres may be favoured parameters, for assessing inhibition of scarring. A treated scar may preferably have improved ECM orientation (i.e. orientation that is more similar to unscarred skin than is the orientation in an untreated scar).

A treated scar will preferably demonstrate inhibition of scarring as assessed with reference to at least one of the parameters for microscopic assessment set out above. More preferably a treated scar may demonstrate inhibition of scarring with reference to at least two of the parameters, even more preferably at least three of the parameters, and most preferably all four of these parameters.

It will be appreciated that inhibition of scarring achieved using the medicaments or methods of the invention may be indicated by improvement of one or more suitable parameters combined from different assessment schemes (e.g. inhibition as assessed with reference to at least one parameter used in macroscopic assessment and at least one parameter used in microscopic assessment).

Further examples of suitable parameters for the clinical measurement and assessment of scars may be selected based upon a variety of measures or assessments including those described by Duncan *et al.* (2006), Beausang *et al.* (1998) and van Zuijlen *et al.* (2002). Except for where the context requires otherwise, many of the following parameters may be applied to macroscopic and/or microscopic assessment of scarring. Examples of Suitable parameters for assessment of scars in the skin may include:

*1. Assessment with regard to Visual Analogue Scale (VAS) scar score.*

Prevention, reduction or inhibition of scarring may be demonstrated by a reduction in the VAS score of a treated scar when compared to a control scar. A suitable VAS for use in the assessment of scars may be based upon the method described by Duncan *et al.* (2006)

or by Beausang *et al.* (1998). This is typically a 10cm line in which 0cm is considered an imperceptible scar and 10cm a very poor hypertrophic scar.

***2. Assessment with regard to a categorical scale.***

Prevention, reduction or inhibition of scarring may be determined by allocating scars to different categories based on either textual descriptions e.g. "barely noticeable", "blends well with normal skin", "distinct from normal skin", etc., by comparing a treated scar and a an untreated or control scar, noting any differences between these, and allocating the differences to selected categories (suitable examples of which may be "mild difference", "moderate difference", "major difference", etc.). Assessment of this sort may be performed by the patient, by an investigator, by an independent panel, or by a clinician, and may be performed either directly on the patient or on photographs or moulds taken from the patient. Inhibition of scarring may be demonstrated when an assessment indicates that treated scars are generally allocated to more favourable categories than are untreated or control scars.

***3. Scar height, scar width, scar perimeter, scar area or scar volume.***

The height and width of scars can be measured directly upon the subject, for example by use of manual measuring devices such as callipers, or automatically with the use of profilometers. Scar width, perimeter and area may be measured either directly on the subject, by image analysis of photographs of the scar, or using plaster casts of impressions of the scar. The skilled person will also be aware of further non-invasive methods and devices that can be used to investigate suitable parameters, including silicone moulding, ultrasound, optical three-dimensional profilimetry and high resolution Magnetic Resonance Imaging.

Inhibition of scarring may be demonstrated by a reduction in the height, width, area, perimeter or volume, or any combination thereof, of a treated scar as compared to an untreated scar.

### *4. Scar distortion and mechanical performance*

Scar distortion may be assessed by visual comparison of a scar and unscarred skin. A suitable comparison may categorise a selected scar as causing no distortion, mild distortion, moderate distortion or severe distortion.

The mechanical performance of scars can be assessed using a number of non-invasive methods and devices based upon suction, pressure, torsion, tension and acoustics. Suitable examples of devices capable of use in assessing mechanical performance of scars include Indentometer, Cutometer, Reviscometer, Visco-elastic skin analysis, Dermaflex, Durometer, Dermal Torque Meter and Elastometer.

Inhibition of scarring may be demonstrated by a reduction in distortion caused by treated scars as compared to that caused by untreated scars. It will also be appreciated that inhibition of scarring may be demonstrated by the mechanical performance of unscarred skin being more similar to that of treated scars than of untreated scars.

**Photographic Assessments**

***Independent Lay Panel***

Photographic assessment of treated and untreated scars may be performed by an independent lay panel of assessors using standardised and calibrated photographs of the scars. The scars may be assessed by an independent lay panel to provide categorical ranking data (e.g. that a given treated scar is "better", "worse" or "no different" when compared to an untreated scar) and quantitative data using a Visual Analogue Scale (VAS) based upon the method described by Duncan *et al.* (2006) and Beausang *et al.* (1998). The capture of these data may make use of suitable software and/or electronic system(s) as described in the applicant's co-pending patent application filed as PCT/GB2005/004787.

***Expert Panel***

Photographic assessment of treated and untreated scars may alternatively or additionally be performed by a panel of expert assessors using standardised and calibrated photographs of the scars to be assessed, and/or positive casts of silicone moulds. The

panel of experts may preferably consist of individuals skilled in the art, suitable examples of which include plastic surgeons, dermatologists or scientists having relevant technical backgrounds.

***Clinical assessment***

A clinician, or an independent panel of clinicians may assess the scar(s) on a patient using any of the forgoing parameters; e.g. VAS, colour, categorical scales, etc. A suitable clinician may be a clinician responsible for care of a patient, or may be a clinician investigating efficacy of therapies for inhibition of scarring.

***Patient assessment***

A patient may assess their own scars and/or compare scars by means of a structured questionnaire. A suitable questionnaire may measure parameters such as: the patient's satisfaction with their scar; how well the scar blends with the unscarred skin; as well as the effect of the scar on their daily life (suitable questions may consider whether the patient uses clothes to hide the scar, or otherwise avoids exposing it) and/or scar symptoms (examples of which may include itch, pain or paresthesia). Inhibition of scarring may be indicated by the treated scar receiving a more positive rating from the patient, and/or causing the patient fewer problems, and/or causing fewer or less scar symptoms, and/or an increase in patient satisfaction compared to an untreated scar.

In addition to categorical data, quantitative data (preferably relating to the above parameters) can be generated using image analysis in combination with suitable visualisation techniques. Examples of suitable visualisation techniques that may be employed in assessing scar quality are specific histological stains or immuno-labelling, wherein the degree of staining or labelling present may be quantitatively determined by image analysis

Quantitative data may be usefully and readily produced in relation to the following parameters:

1. Scar width, height, elevation, volume and area.
2. Collagen organisation, collagen fibre thickness, collagen fibre density.

2. Number and orientation of fibroblasts.

4. Quantity and orientation of other ECM molecules e.g. elastin, fibronectin

Prevention, reduction or inhibition of scarring may be demonstrated by a change in any of the parameters considered above such that a treated scar more closely resembles unscarred skin than does a control or untreated scar (or other suitable comparator).

The assessments and parameters discussed above are suitable for assessment of the effects of WNT3A, or its fragments or derivatives, on scar formation, as compared to control, placebo or standard care treatment in animals or humans. It will be appreciated that these assessments and parameters may be utilised in determining therapeutically effective fragments or derivatives of WNT3A that may be used for scar prevention, reduction or inhibition; and in determining therapeutically effective amounts of WNT3A, or its fragments or derivatives. Appropriate statistical tests may be used to analyse data sets generated from different treatments in order to investigate significance of results.

Many of the parameters described above for the assessment of scarring have previously been described with reference to the assessment of scarring that results from healing of a wound. However, the inventors believe that many of these parameters are also suitable for assessment of scarring associated with fibrotic disorders. Additional or alternative parameters that may be considered when assessing scarring associated with fibrotic disorders will be apparent to the skilled person. The following examples are provided by way of illustration only.

Scarring associated with fibrotic disorders may be assessed with reference to trichrome staining (for example Masson's trichrome or Mallory's trichrome) of biopsy samples taken from treated or non-treated tissues believed to be subject to the fibrotic disorder. These samples may be compared with non-scarred tissues that have been taken from tissues not subject to the fibrotic disorder, and with reference tissues representative of staining in the same tissue (or a range of tissues) subject to different extents of scarring associated with the fibrotic disorder. Comparisons of such tissues may allow assessment of the presence and extent of scarring associated with a fibrotic disorder that is present in

the tissue of interest. Protocols for trichrome staining are well known to the skilled person, and kits that may be used to conduct trichrome staining are commercially available.

It will be appreciated that in many cases it may be preferred to avoid invasive procedures such as the collection of biopsies. In recognition of this fact a number of non-invasive procedures have been devised that allow assessment of scarring associated with fibrotic disorders without the need for biopsy samples. Examples of such procedures include Fibrotest (FT) and Actitest (AT).

These commercially available assays use five or six biochemical markers of scarring associated with fibrotic disorders for use as a non-invasive alternative to liver biopsy in patients with chronic hepatitis C or B, alcoholic liver disease and metabolic steatosis (for instance the overweight, patients with diabetes or hyperlipidemia). Through use of such biochemical markers, and analysis using selected algorithms, these procedures are able to determine levels of liver fibrosis and necroinflammatory activity. The use of such tests is increasingly clinically accepted as an alternative to biopsies, and the tests are commercially available from suppliers such as BioPredictive.

It will be appreciated by the skilled person that the methods described above may be used to allow assessment of scarring that is associated with one or more fibrotic disorders in order to determine whether or not prevention, reduction or inhibition of such scarring utilising the medicaments or methods of the invention would be advantageous. Furthermore, scar assessment methods of the type described above may be used to determine therapeutically effective fragments or derivatives of WNT3A suitable for inhibition of scarring associated with a fibrotic disorder, as well as determining therapeutically effective amounts of WNT3A, or its fragments or derivatives.

**Preferred routes of administration for use in accordance with the invention**

It may generally be preferred that therapeutically effective amounts of WNT3A, or of therapeutically effective fragments or derivatives thereof, are provided to a tissue, the

scarring of which is to be inhibited, by local administration. Suitable methods by which such local administration may be achieved will depend on the identity of the tissue in question, and may also be influenced by whether the scarring to be inhibited is scarring resulting from the healing of a wound, or scarring associated with a fibrotic disorder. Preferred routes of administration may include local injection (for example intradermal injection in the case where it is wished to inhibit scarring of the skin). Other suitable means of administration include the use of topical medicaments such as sprays; powders; drops (e.g. for the ear or eye); ointments or creams; or release from local devices e.g. stents, implants, polymers, dressings etc.

Scarring associated with fibrotic disorders will frequently occur in relatively inaccessible tissues and organs, and it may be preferred that when scarring associated with a fibrotic disorder is to be inhibited the WNT3A, or fragment or derivative thereof, be administered systemically. Suitable routes of administration include, without limitation, oral, transdermal, inhalation, parenteral, sublingual, rectal, vaginal and intranasal. By way of example, solid oral formulations (such as tablets or capsules) providing a therapeutically effective amount of WNT3A, or a fragment or derivative thereof, may be used for the inhibition of scarring associated with renal fibrosis or cirrhosis of the liver. Aerosol formulations for inhalation may be preferred as means for providing WNT3A, or therapeutically effective fragments or derivatives thereof, in the event that it is wished to inhibit scarring associated with chronic obstructive pulmonary disease or other fibrotic disorders of the lungs and airways.

It will be appreciated that many of the routes of administration described above may also be suitable for topical administration to a tissue in which it is wished to inhibit scarring (for example, inhalation or intranasal administration for inhibition of scarring in the respiratory system, whether as a result of the healing of a wound, or associated with a fibrotic disorder).

The methods or medicaments of the invention may be used prophylactically, i.e. prior to scar formation. For example, methods or medicaments of the invention may be utilised prior to wounding or prior to the onset of a fibrotic disorder.

In the case of the inhibition of scarring associated with healing of a wound, this may involve administration of a therapeutically effective amount of WNT3A, or fragments or derivatives thereof, at sites where no wound presently exists, but where a wound that would otherwise give rise to a scar is to be formed. By way of example, a therapeutically effective amount of WNT3A, or a fragment or derivative thereof, may be administered to sites that are to undergo wounding as a result of elective procedures (such as surgery), or to sites that are believed to be at elevated risk of wounding.

It may be preferred that the medicaments of the invention are administered to the site around the time of wounding, or immediately prior to the forming of a wound (for example in the period up to six hours before wounding) or the medicaments may be administered at an earlier time before wounding (for example up to 48 hours before a wound is formed). The skilled person will appreciate that the most preferred times of administration prior to formation of a wound will be determined with reference to a number of factors, including the formulation and route of administration of the selected medicament, the dosage of the medicament to be administered, the size and nature of the wound to be formed, and the biological status of the patient (which may determined with reference to factors such as the patient's age, health, and predisposition to healing complications or adverse scarring). The prophylactic use of methods and medicaments in accordance with the invention is a preferred embodiment of the invention, and is particularly preferred in the prevention, reduction or inhibition of scarring in the context of surgical wounds.

In the case of the inhibition of scarring associated with fibrotic disorders medicaments of the invention may be administered to a site at elevated risk of developing a fibrotic disorder prior to formation of said disorder. Suitable sites may be those that are perceived to be at elevated risk of the development of fibrotic disorders. An elevated risk of development of fibrotic disorders may arise as a result of disease, or as a result of environmental factors (including exposure to fibrotic agents), or as a result of genetic predisposition.

When used for the inhibition of scarring associated with fibrotic disorder, a therapeutically effective amount of WNT3A, or a fragment or derivative thereof, may be administered immediately prior to onset of a fibrotic disorder, or at an earlier time. The skilled person will be able to establish the optimal time for administration of medicaments of the invention used to treat fibrotic disorders using standard techniques well known to those skilled in the art, and familiar with the clinical progression of scarring associated with fibrotic disorders.

The methods and medicaments of the invention are also able to inhibit scarring if administered after a wound has already been formed. It is preferred that such administration should occur as early as possible after formation of the wound, but agents of the invention are able to inhibit scarring at any time up until the healing process has been completed (i.e. even in the event that a wound has already partially healed the methods and medicaments of the invention may be used to inhibit scarring in respect of the remaining un-healed portion). It will be appreciated that the "window" in which the methods and medicaments of the invention may be used to inhibit scarring is dependent on the nature of the wound in question (including the degree of damage that has occurred, and the size of the wounded area). Thus, in the case of a large wound, the methods and medicaments of the invention may be administered relatively late in the healing response yet still be able to inhibit scarring, as a consequence of the relatively prolonged time that large wounds require to heal.

The methods and medicaments of the invention may, for instance, preferably be administered within the first 24 hours after a wound is formed, but may still inhibit scarring if administered up to ten, or more, days after wounding.

Similarly, the methods and medicaments of the invention may be administered to a site at which a fibrotic disorder is already developing, in order to prevent further scarring associated with the fibrotic disorder taking place. This use will obviously be advantageous in situations in which the degree of scarring that has occurred prior to administration of WNT3A, or therapeutically effective fragment or derivative thereof, is sufficiently low that the fibrotic tissue is still able to function.

Medicaments of the invention may preferably be administered within 24 hours of the onset of scarring associated with a fibrotic disorder, but may still be effective if administered considerably later in the fibrotic process. For example, medicaments may be administered within a month of the onset of the fibrotic disorder (or of the diagnosis that scarring associated with the fibrotic disorder is taking place), or within sixth months, or even one or more years, depending on the extent of scarring that has already occurred, the proportion of the tissue effected by the fibrotic disorder, and the rate at which the fibrotic disorder is progressing.

The methods and medicaments of the invention may be administered on one or more occasions (as necessary) in order to inhibit scarring.

For instance, in the case of inhibition of scarring that results from the healing of a wound, therapeutically effective amounts of WNT3A, or a fragment or derivative thereof, may be administered to a wound as often as required until the healing process has been completed. By way of example, the medicaments of the invention may be administered daily or twice daily to a wound for at least the first three days following the formation of the wound. In a particularly preferred embodiment a medicament of the invention may be administered prior to wounding and again approximately 24 hours following wounding.

Most preferably the methods or medicaments of the invention may be administered both before and after formation of a wound. The inventors have found that administration of the medicaments of the invention immediately prior to the formation of a wound, followed by daily administration of WNT3A, or a therapeutically effective fragment or derivative thereof, for one or more days following wounding, is particularly effective in inhibiting scarring resulting from the healing of a wound, or associated with a fibrotic disorder.

In the case where WNT3A, or a therapeutically effective fragment or derivative thereof, is to be used to inhibit scarring associated with a fibrotic disorder, a therapeutically effective amount of the WNT3A, or fragment or derivative, may be provided by means of a number

of administrations. Suitable regimes may involve administration monthly, weekly, daily or twice daily.

The inventors believe that therapeutically effective amounts of WNT3A, or its fragments or derivatives, may also be used to reduce existing scars. This is applicable to existing scars that result from the healing of a wound, and/or existing scars associated with fibrotic disorders. Accordingly the use of methods and medicaments of the invention in the reduction of existing scars constitutes a preferred use according to the invention. A therapeutically effective amount of WNT3A, or a fragment or derivative thereof, may be provided by means of any number of suitable administrations. Suitable regimes for these administrations may be readily devised by the skilled person using techniques (including *in vitro* studies, animal and human studies) well known in and established within the pharmaceutical industry.

The term "active agent" has been defined elsewhere in the specification. For the present purposes the terms "agent" or "agent of the invention" should be taken to have an equivalent meaning. It will be appreciated that all such suitable active agents may be incorporated in medicaments in accordance with the invention, and all may be used in the methods or uses of the invention. The medicaments of the invention represent preferred compositions by which a therapeutically effective amount of an active agent may be administered in order to put the methods of the invention into practice.

It will be appreciated that the amount of a medicament of the invention that should be provided to a wound or fibrotic disorder, in order that a therapeutically effective amount of an active agent may be administered, depends on a number of factors. These include the biological activity and bioavailability of the agent present in the medicament, which in turn depends, among other factors, on the nature of the agent and the mode of administration of the medicament. Other factors in determining a suitable therapeutic amount of a medicament may include:

A) The half-life of the active agent in the subject being treated.

B) The specific condition to be treated (e.g. acute wounding or chronic fibrotic disorders).

C) The age of the subject.

D) The size of the site to be treated.

The frequency of administration will also be influenced by the above-mentioned factors and particularly the half-life of the chosen agent within the subject being treated.

Generally, medicaments of the invention may be formulated and manufactured in any form that allows for the medicament to be administered to a patient such that a therapeutically effective amount of WNT3A, or a fragment or derivative thereof, is provided to a site where scarring is to be prevented, reduced or inhibited.

Medicaments of the invention may preferably be provided in the form of one of more dosage units providing a therapeutically effective amount (or a known fraction or multiple of a therapeutically effective amount) of WNT3A, or a fragment or derivative thereof. Methods of preparing such dosage units will be well known to the skilled person; for example see Remington's Pharmaceutical Sciences 18th Ed. (1990).

Generally when medicaments in accordance with the invention are used to treat existing scars (whether resulting from healing of a wound, or associated with a fibrotic disorder) the medicament should be administered as early as possible in the scarring process or the fibrotic disorder begins. In the case of wounds or fibrotic disorders that are not immediately apparent, such as those at internal body sites, medicaments may be administered as soon as the wound or disorder, and hence the risk of scarring, is diagnosed. Therapy with methods or medicaments in accordance with the invention should continue until scarring has been inhibited to a clinician's satisfaction.

Frequency of administration will depend upon the biological half-life of the agent used. Typically a cream or ointment containing an agent of the invention should be administered to a target tissue such that the concentration of the agent at a wound or site of fibrosis is maintained at a level suitable to inhibit scarring. This may require

administration daily or even several times daily. The inventors have found that administration of an agent of the invention immediately prior to wounding, with a further administration one day after wounding is particularly effective for the inhibition of scarring that would otherwise result from the healing of such a wound.

Medicaments of the invention, may be administered by any suitable route capable of achieving the desired effect of inhibiting scarring, but it is preferred that the medicaments be administered locally at a wound site or site of a fibrotic disorder.

The inventors have found that the inhibition of scarring may be effected by the administration of an agent of the invention by injection at a wound site or site of a fibrotic disorder. For instance, in the case of skin wounds or skin fibrosis, agents of the invention may be administered by means of intradermal injection. Thus a preferred medicament in accordance with the invention comprises an injectable solution of an agent of the invention (e.g. for injection around the margins of a wound, or at a site likely to be wounded). Suitable formulations for use in this embodiment of the invention are considered below.

Alternatively, or additionally, medicaments of the invention may also be administered in a topical form to inhibit scarring (whether resulting from the healing of a wound, or associated with a fibrotic disorder). In the case of inhibiting scarring that would otherwise result from healing of a wound, such administration may be effected as part of the initial and/or follow up care for the wounded area.

The inventors have found that inhibition of scarring can be very beneficially effected by topical application of an agent of the invention to a wound or fibrotic disorder (or, in the case of prophylactic application, to a tissue or site where a wound or fibrotic disorder will occur).

**Preferred formulations for use in accordance with the invention**

Compositions or medicaments containing active agents may take a number of different forms depending, in particular, on the manner in which they are to be used. Thus, for example, they may be in the form of a liquid, ointment, cream, gel, hydrogel, powder or aerosol. All of such compositions are suitable for topical application to a site of scarring (for example, either a wound or a fibrotic disorder), and this represents a preferred means of administering agents of the invention to a subject (person or animal) in need of treatment.

The agents of the invention may be provided on a sterile dressing or patch, which may be used to cover a wound or fibrotic site where scarring is to be inhibited.

The agents of the invention may be released from a device or implant, or may be used to coat such a device e.g. a stent or controlled release device e.g. wound dressing.

It will be appreciated that the vehicle of a composition comprising agents of the invention should be one that is well tolerated by the patient and allows release of the agent to the wound or fibrotic site. Such a vehicle is preferably biodegradeable, bioresolveable, bioresorbable and/or non-inflammatory.

Medicaments and compositions comprising agents of the invention may be used in a number of ways. Thus, for example, a composition may be applied in and/or around a wound or fibrotic disorder in order to inhibit scarring. If the composition is to be applied to an existing wound or fibrotic site, then the pharmaceutically acceptable vehicle will be one which is relatively "mild" i.e. a vehicle which is biocompatible, biodegradable, bioresolvable and non-inflammatory.

An agent of the invention, or a nucleic acid encoding such an agent (as considered further below), may be incorporated within a slow or delayed release device. Such devices may, for example, be placed on or inserted under the skin and the agent or nucleic acid may be released over days, weeks or even months.

Delayed release devices may be particularly useful for patients, such as those suffering from extensive or pathological scarring or from long-lasting scarring associated with a fibrotic disorder, who require long-term administration of therapeutically effective amounts of WNT3A, or its fragments or derivatives. Such devices may be particularly advantageous when used for the administration of an agent or nucleic acid that would otherwise normally require frequent administration (e.g. at least daily administration by other routes).

Daily doses of an agent of the invention may be given as a single administration (e.g. a daily application of a topical formulation or a daily injection). Alternatively, the agent of the invention may require administration twice or more times during a day. In a further alternative, a slow release device may be used to provide optimal doses of an agent of the invention to a patient without the need to administer repeated doses.

A dose of a composition comprising an active agent may preferably be sufficient to provide a therapeutically effective amount of WNT3A, or a fragment or derivative thereof, in a single administration. However, it will be appreciated that each dose need not in itself provide a therapeutically effective amount of an active agent, but that a therapeutically effective amount may instead be built up through repeated administration of suitable doses.

Various suitable forms are known for compositions comprising agents of the invention. In one embodiment a pharmaceutical vehicle for administration of an active agent may be a liquid and a suitable pharmaceutical composition would be in the form of a solution. In another embodiment, the pharmaceutically acceptable vehicle is a solid and a suitable composition is in the form of a powder. In a further embodiment the active agent may be formulated as a part of a pharmaceutically acceptable transdermal delivery system, e.g., a patch/dressing

A solid vehicle can include one or more substances that may also act as flavouring agents, lubricants, solubilizers, suspending agents, fillers, glidants, compression aids, binders or tablet-disintegrating agents; it can also comprise an encapsulating material. In powders,

the vehicle is a finely divided solid that is in admixture with the finely divided agent of the invention. In tablets, the agent of the invention is mixed with a vehicle having the necessary compression properties in suitable proportions and compacted in the shape and size desired. The powders and tablets preferably contain up to 99% of the agent of the invention. Suitable solid vehicles include, for example, calcium phosphate, magnesium stearate, talc, sugars, lactose, dextrin, starch, gelatin, cellulose, polyvinylpyrrolidine, low melting waxes and ion exchange resins.

Liquid vehicles may be used in preparing solutions, suspensions, emulsions, syrups, elixirs and pressurized compositions. The active agent can be dissolved or suspended in a pharmaceutically acceptable liquid vehicle such as water, an organic solvent, a mixture of both or pharmaceutically acceptable oils or fats. The liquid vehicle can contain other suitable pharmaceutical additives such as solubilizers, emulsifiers, buffers, preservatives, sweeteners, flavouring agents, suspending agents, thickening agents, colours, viscosity regulators, stabilizers or osmo-regulators. Suitable examples of liquid vehicles for oral and parenteral administration include water (partially containing additives as above, e.g. cellulose derivatives, preferably sodium carboxymethyl cellulose solution), alcohols (including monohydric alcohols and polyhydric alcohols, e.g. glycols) and their derivatives, and oils (e.g. fractionated coconut oil and arachis oil). For parenteral administration, the vehicle can be an oily ester such as ethyl oleate and isopropyl myristate. Sterile liquid vehicles are useful in sterile liquid form compositions for parenteral administration. The liquid vehicle for pressurized compositions can be halogenated hydrocarbon or other pharmaceutically acceptable propellant.

Liquid pharmaceutical compositions which are sterile solutions or suspensions can be utilized by, for example, intramuscular, intrathecal, epidural, intraperitoneal, intradermal, intrastromal (cornea), intraadventitial (blood vessels) or subcutaneous injection. Sterile solutions can also be administered intravenously. The agent of the invention may be prepared as a sterile solid composition that may be dissolved or suspended at the time of administration using sterile water, saline, or other appropriate sterile injectable medium (such as PBS). Vehicles are intended to include necessary and inert binders, suspending agents, lubricants and preservatives.

In the situation in which it is desired to administer an agent of the invention by means of oral ingestion, it will be appreciated that the chosen agent will preferably be an agent having an elevated degree of resistance to degradation. For example, the active agent may be protected (using the techniques well known to those skilled in the art) so that its rate of degradation in the digestive tract is reduced.

As set out elsewhere in the specification, compositions of agents of the invention are suitable for use in inhibiting scarring in the eye (and particularly in the cornea or retina). Scarring of the cornea may result from corneal wounds, which may be caused by trauma to the cornea arising as a result of accidental injury or as a result of surgical operations (e.g. laser surgery on the cornea). In the case of administration of agents of the invention to the outer surfaces of the eye, such as the cornea, a preferred medicament of the invention may be in the form of an eye drop (including viscous or semi-viscous eye drops), cream, gel or ointment.

Scarring in the eye may also be associated with fibrotic disorders such as proliferative vitreoretinopathy. In the event that it is wished to inhibit scarring associated with fibrotic disorders such as proliferative vitreoretinopathy, it may be preferred to administer a therapeutically effective amount of an active agent by means of intravitreal injection or localised (e.g. intraocular) release device. Such injections may preferably follow surgery or intravitreal implantation procedures.

Agents of the invention may be used to inhibit scarring in a range of "internal" wounds or fibrotic disorders (i.e. wounds or fibrotic disorders occurring within the body, rather than on an external surface). Examples of internal wounds include penetrative wounds that pass through the skin into underlying tissues, and wounds associated with surgical procedures conducted within the body. The range of fibrotic disorders that effect internal sites is extensive, and includes lung fibrosis, liver fibrosis, kidney fibrosis and muscle fibrosis.

In a preferred example, medicaments in accordance with the invention for use in the inhibition of scarring in the lungs or other respiratory tissues may be formulated for inhalation.

In a preferred example, medicaments in accordance with the invention for use in the inhibition of scarring in the body cavities e.g. abdomen or pelvis, may be formulated as a lavage, gel or instillate.

WNT3A, or a therapeutically effective fragment or derivative thereof, for use in the medicaments or methods of the invention, may be incorporated in a biomaterial, from which it may be released to inhibit scarring. Biomaterials incorporating active agents are suitable for use in many contexts, and at many body sites, where it is desired to inhibit scarring, but may be of particular utility in providing WNT3A, or a fragment or derivative thereof, to the eye (for example after retina surgery or glaucoma filtration surgery), or to sites where it is wished to inhibit restenosis or adhesions. The inventors believe that biomaterials incorporating active agents may be used in the manufacture of sutures, and such sutures represent a preferred embodiment of a medicament of the invention.

Known procedures, such as those conventionally employed by the pharmaceutical industry (e.g. *in vivo* experimentation, clinical trials etc), may be used to establish specific formulations of compositions comprising agents of the invention and precise therapeutic regimes for administration of such compositions (such as daily doses of the active agent and the frequency of administration).

A suitable dose of an agent in accordance with the invention able to inhibit scarring may depend upon a range of factors including (but not limited to) the nature of the tissue to be treated, the area and/or depth of the wound or fibrosis to be treated, the severity of the wound or fibrosis, and the presence or absence of factors predisposing to pathological scar formation.

The inventors believe that the amount of WNT3A, or a therapeutically effective fragment or derivative thereof, that may be administered to a wound or site of fibrosis in a single

incidence of treatment may preferably be in the region of 2.4 fmoles to 24 pmoles/cm of wound or $cm^2$ of fibrosis.

For the purposes of the present disclosure, a centimetre of wound may be taken to comprise a site where a wound is to be formed, as well as a wounded site, or both margins of a wounded site (should such margins exist).

A centimetre of wound in the context of the present disclosure constitutes a unit by which the size of a wound to be treated may be measured. A centimetre of wound may be taken to comprise any square centimetre of a body surface that is wounded in whole or in part. For example, a wound of two centimetres length and one centimetre width (i.e. with a total surface area of two centimetres$^2$) will be considered to constitute "two wound centimetres", while a wound having a length of two centimetres and a width of two centimetres (i.e. a total surface area of four centimetres$^2$) will constitute four wound centimetres. By the same token, a linear wound of two centimetres length, but of negligible width (i.e. with negligible surface area), will, for the purposes of the present invention, be considered to constitute "two wound centimetres", if it passes through two square centimetres of the body surface.

The size of a wound in wound centimetres should generally be assessed when the wound is in its relaxed state (i.e. when the body site bearing the wounded area is in the position adopted when the body is at rest). In the case of skin wounds, the size of the wound should be assessed when the skin is not subject to external tension.

By way of further example, the preferred amount of WNT3A, or a therapeutically effective fragment or derivative thereof, to be administered to a wound or site of fibrosis over a period of approximately 24 hours may be up to 24 pmoles/cm of wound or $cm^2$ of fibrosis.

In the event that a fragment or derivative of WNT3A comprises a different numbers of receptor binding sites to the number of receptor binding sites found in native WNT3A, this may alter the number of moles of such a fragment or derivative required in order to

provide a therapeutically effective amount. For example, in the event that a derivative of WNT3A comprises twice the number of binding sites present in native WNT3A, the amount of the derivative that will be needed to provide a therapeutically effective amount will generally be half of the amount(s) suggested above. Other such variations will be readily apparent to the skilled person.

The skilled person will appreciate that the suggestions above are provided for guidance. In particular it will be appreciated that the amount of WNT3A, or a therapeutically effective fragment or derivative thereof, to be administered via topical administration may be altered depending on permeability of the tissue or organ to which the topical composition is administered. Thus, in the case of relatively impermeable tissues or organs, it may be preferred to increase the amount of WNT3A, or a therapeutically effective fragment or derivative thereof, to be administered. Such an increased amount of WNT3A, or fragment or derivative thereof, may still represent a therapeutically effective amount, if the amount of the agent taken up into the tissue or organ where scarring is to be inhibited is therapeutically effective (i.e. if a therapeutically effective amount permeates the tissue or organ where scarring is to be inhibited, irrespective of the fact that a larger, non-therapeutic, amount of the agent may remain on the surface of, and unable to penetrate, the tissue or organ being treated).

The inventors believe that the amount of WNT3A, or a therapeutically effective fragment or derivative thereof, to be administered to a wound, or site of fibrosis, in a single incidence of treatment will preferably not exceed about 24 pmoles/cm of wound, or $cm^2$ of fibrosis. More preferably the amount administered in a single incidence of treatment will be less than about 12 pmoles/cm of wound, or $cm^2$ of fibrosis, and most preferably it may be in the region of between 24 fmoles and 2.4 pmoles of wound, or $cm^2$ of fibrosis.

Most preferably WNT3A may be administered in an amount of approximately 1ng per linear centimetre of wound or $cm^2$ of fibrosis over a 24 hour period.

The skilled person will appreciate that effective therapeutic amounts of WNT3A, or a fragment or derivative thereof, may be determined with reference to the concentration of

the agent that is attained in the organ or tissue to which they are administered. The information regarding therapeutically effective dosages set out herein will provide sufficient guidance to allow the skilled person to calculate the local concentrations of an active agent established by intradermal injection, and, based on these values, to determine suitable amounts of such agents that may be administered by other routes in order to achieve equivalent local concentrations.

It will be appreciated that the guidance as to doses and amounts of an active agent to be used provided above is applicable both to medicaments of the invention, and also to the methods of the invention.

The inventors have found that WNT3A may particularly preferably be administered in the form of a 1ng/100µl solution, with 100µl of such a solution provided per centimetre of wound or fibrosis in a 24 hour period.

In the case where the paragraphs above consider the administration of a specified amount of a medicament per linear cm of a wound it will be appreciated that this volume may be administered to either one or both of the margins of a wound to be treated (i.e. in the case of a reference to 100µl of a medicament, this may be administered as 100µl to the wound margins, or as 50µl to each of the wound margins to be joined together).

The skilled person will recognise that the information provided in the preceding paragraphs as to amounts of WNT3A, or a therapeutically effective fragment or derivative thereof, which may be administered to wounds or sites of fibrotic disorders in order to inhibit scarring, may be varied by the skilled practitioner in response to the specific clinical requirements of an individual patient. For example, it will be appreciated that in the case of particularly deep or wide wounds the amounts provided by way of guidance above may be varied upwards, while still providing a therapeutically effective amount of WNT3A, or a fragment or derivative thereof. Suitable variations based on the guidance provided above will be readily apparent to those of skill in the art.

Medicaments of the invention may be used to inhibit scarring as a monotherapy (e.g. through use of medicaments of the invention alone). Alternatively the methods or medicaments of the invention may be used in combination with other compounds or treatments for the inhibition of scarring. Suitable compounds that may be used as parts of such combination therapies will be well known to those skilled in the art.

**Gene therapy**

The skilled person will appreciate that therapeutically effective amounts of WNT3A, or its fragments or derivatives, may be provided at sites where it is wished to inhibit scarring by virtue of cellular expression (commonly referred to as gene therapy). Such cellular expression must be controlled in order to prevent the accumulation of non-therapeutic amounts of such active agents, or even amounts that are capable of exacerbating scarring or fibrosis. Accordingly, the invention provides a method of inhibiting scar formation, the method comprising inducing cellular expression of a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, at a site where scarring is to be inhibited. Such a site may, for example be a wound, or a site of a fibrotic disorder.

Based on the teaching contained in the present specification, it will be a matter of routine experimentation for one skilled in the art to devise protocols by which cells may be induced to express therapeutically effective amounts of WNT3A (or its fragments or derivatives).

For example, the skilled person will appreciate that such cellular expression of therapeutically effective amounts of WNT3A may be achieved by manipulating naturally occurring expression of this molecule by cells in the region of the site to be treated.

Alternatively, and preferably, cells in the region of the site to be treated may be induced to express WNT3A, or therapeutically effective fragments or derivatives thereof, by means of the introduction of materials encoding such agents. Suitable materials may

typically comprise nucleic acids such as DNA or RNA, and these may be devised based upon the sequences referred to in this specification.

Nucleic acids for use in this embodiment of the invention may be administered "as is", for example by means of ballistic transfection, or as parts of a larger construct, which may be able to incorporate stably into cells so transfected. Suitable constructs may also contain regulatory elements, by which expression of a therapeutically effective amount of WNT3A, or a fragment or derivative thereof, may be achieved. Such constructs give rise to further aspects of the present invention.

Thus the invention also provides a construct encoding WNT3A, or a therapeutically effective fragment or derivative thereof, said construct being capable of expression, at a site where scarring is to be inhibited, to give rise to a therapeutically effective amount of the WNT3A, or therapeutically effective fragment or derivative. The invention also provides a method of inhibiting scarring, the method comprising administering a construct (as described above) to a site where scarring is to be inhibited such that a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, is expressed. The invention also provides the use of such a construct in the manufacture of a medicament for the inhibition of scarring.

It will be appreciated that many of the advantages that may be gained as a result of inhibiting scarring of humans are also are also applicable to other animals, particularly veterinary or domestic animals (e.g. horses, cattle, dogs, cats etc). Accordingly it will be recognised that the medicaments and methods of the invention may also be used inhibit scarring of non-human animals. Generally the same active agents that may be used to inhibit scarring of humans may also be used in such cases, however it may be preferred to use WNT3A (or a therapeutically effective fragment or derivative thereof) that is derived from the same type of animal as is being treated (e.g. in the case of treatment of horses, use of equine WNT3A).

The invention will now be further described with reference to the following Experimental Results and Figures in which:

Figure 1 compares macroscopic VAS scores for treated, untreated and control treated wounds assessed 70 days after wounding. In this Figure "*" indicates $p < 0.05$ versus naive and diluent controls.

Figure 2 compares microscopic VAS scores for treated, untreated and control treated wounds assessed 70 days after wounding. In this Figure "*" indicates $p < 0.05$ versus naive and diluent controls.

Figure 3 compares representative images of WNT3A treated wounds (panel A, treated with WNT3A at a concentration of 1ng/100µl) and untreated (naïve) wound (panel B).

Details of the amino acid and nucleotide sequences referred to elsewhere in the specification are also set out under the heading "Sequence Information".

## Experimental Results

The inventors investigated the ability of WNT3A to inhibit scarring using in an *in vivo* model of scarring.

**Incisional wound healing model and treatment with WNT3A**

Murine WNT3A (Catalogue number 1324-WN/CF, Lot HTR054051) was purchased from R&D Systems.

The WNT3A was diluted in phosphate buffered saline (PBS) to produce three solutions having concentrations as follows:

1. 1ng/100µl (a 0.24 nM solution);
2. 10ng/100µl (a 2.4 nM solution); and
3. 100ng/100µl (a 24 nM solution).

PBS alone was used as a diluent control.

**Scarring model, dosing and harvest timepoint**

At day 0, Male Sprague Dawley rats (200-250g) were anaesthetised, shaved and wound sites were marked according to the following wounding template: 2 x 1cm wounds incisional wounds formed 5cm from the base of the skull and 1cm from the midline of each rat. One hundred microlitres of WNT3A incorporated in the solutions described above (1ng, 10ng or 100ng of WNT3A in 100µl of PBS), were injected intradermally at the sites where wounds were to be formed. The intradermal injections caused the formation of a raised bleb, which was then immediately incised to form 1cm long full thickness experimental wounds. A separate group of rats were wounded, without any injection, to act as the untreated naïve control group in addition to a group receiving diluent control injections (100µl of PBS alone, without WNT3A).

Accordingly, each injection of the 1ng/100µl solution provided 24.4 fmoles of WNT3A, whilst each injection of the10ng/100µl solution provided 244 fmoles of WNT3A, and each injection of the 100ng/100µl solution provided 2.4 pmoles of WNT3A.

All wounds receiving either treatment or diluent control injections were re-injected again 1 day post-wounding with the appropriate solution via injection of 50µl to each of the two margins of the 1cm wound. Wounds were then harvested at day 70 post-wounding.

The wounds were photographed after wounding, prior to re-injection on day 1 and on day of harvest. The wounds were analysed microscopically and macroscopically to assess scarring occurring on the healing of the treated, untreated and control treated wounds.

**Assessment of scarring**

70 days after wounding the experimental rats were killed, and the scars resulting from treated wounds and control wounds assessed both macroscopically and microscopically.

The scars of the experimental rats were photographed and assessed using macroscopic scar assessment sheets. Macroscopic assessment of scarring was carried out using a visual analogue scale (VAS) consisting of a 0-10cm line representing a scale, from left to right, of 0 (corresponding to normal skin) to 10 (indicative of a bad scar). A mark was made by a trained assessor on the 10cm line based on an overall assessment of the scar taking into account parameters such as the height, width, contour and colour of the scar. The best scars (typically of small width, with colour, height and contour like normal skin) were scored towards the normal skin end of the scale (the left hand side of the VAS line) and bad scars (typically large width, raised with uneven contours and whiter colour) were scored towards the bad scar end of the scale (the right hand side of the VAS line). The marks were measured from the left hand side to provide the final value for the scar assessment in centimetres (to 1 decimal place).

For microscopic assessment, the scars were excised from the experimental rats (incorporating a small amount of surrounding normal tissue) and fixed in 10% (v/v) buffered formal saline. The fixed tissue was then processed for wax histology. Histological slides were stained using Masson's trichrome, and scarring assessed by a trained assessor using a microscopic visual analogue scale (VAS). This consisted of a 0-10cm line representing a scale, from left to right, of 0 (corresponding to normal skin) to 10 (indicative of a bad scar). A mark was made on the 10cm line based on an overall assessment of the scar taking into account parameters such as collagen fibre spacing, orientation and thickness. The best scars (typically narrow scars with thick and randomly organised collagen fibres that have normal spacing between fibres, similar to the surrounding normal dermis) were scored towards the normal skin end of the scale (the left hand side of the VAS line) and bad scars (typically wide scars with thin densely packed parallel collagen fibres) were scored towards the bad scar end of the scale (the right hand side of the VAS line). The marks were measured from the left hand side to provide the final value for the scar assessment in centimetres (to 1 decimal place).

A comparison of the macroscopic VAS scores of scars resulting from healing of WNT3A treated wounds and naïve and diluent control wounds is shown in Figure 1.

A comparison of the microscopic VAS scores of scars formed on healing of WNT3A treated wounds and naïve and diluent control wounds is shown in Figure 2.

Representative images showing the macroscopic appearance of scars formed on healing of WNT3A treated wounds and naïve control wounds are shown in Figure 3.

## Results

Both macroscopic and microscopic analysis of scars formed from incisional wounds (assessed at 70 days post-wounding) showed that administration of WNT3A was able to significantly inhibit scarring of such treated wounds.

That scarring is effectively inhibited by use of a therapeutically effective amount of WNT3A is clearly illustrated in Figure 3, which shows representative macroscopic images of a treated scar and naïve control scar. The scar resulting from a wound treated with a therapeutically effective amount WNT3A is considerably more difficult to detect than the scar produced on healing of a naïve control wound.

The results show that a therapeutically effective amount of WNT3A, and hence of a therapeutically effective fragment or derivative of WNT3A, is capable of inhibiting scarring. These results also provide guidance as to how therapeutically effective amounts of such active agents may be determined. The greatest reduction in scarring was observed on administration of a 1ng/100µl solution (in which each administration provided 24.4 fmoles of WNT3A), and this represents a preferred example of a therapeutically effective amount of WNT3A.

Given the similarities between the biological mechanisms involved in scarring that results from healing of a wound and scarring associated with fibrotic disorders the results reported above provide a clear indication that therapeutically effective amounts of WNT3A, or its therapeutically effective fragments or derivatives, may be utilised in the prevention, reduction or inhibition of both scarring resulting from wounds and scarring associated with fibrotic disorders.

## "Sequence Information"

**Sequence ID No. 1 Human WNT3A amino acid sequence**

MAPLGYFLLLCSLKQALGSYPIWWSLAVGPQYSSLGSQPILCASIPGLVPKQLRFCRNYVEIMPSVAEGIKI
GIQECQHQFRGRRWNCTTVHDSLAIFGPVLDKATRESAFVHAIASAGVAFAVTRSCAEGTAAICGCSSRHQG
SPGKGWKWGGCSEDIEFGGMVSREFADARENRPDARSAMNRHNNEAGRQAIASHMHLKCKCHGLSGSCEVKT
CWWSQPDFRAIGDFLKDKYDSASEMVVEKHRESRGWVETLRPRYTYFKVPTERDLVYYEA
SPNFCEPNPETGSFGTRDRTCNVSSHGIDGCDLLCCGRGHNARAERRREKCRCVFHWCCYVSCQECTRVYDV
HTCK

**Sequence ID No. 2 Human WNT3A nucleotide sequence**

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  61 gcgccctctc gcgcggcgat ggccccactc ggatacttct tactcctctg cagcctgaag
 121 caggctctgg gcagctaccc gatctggtgg tcgctggctg ttgggccaca gtattcctcc
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 241 ttctgcagga actacgtgga gatcatgccc agcgtggccg agggcatcaa gattggcatc
 301 caggagtgcc agcaccagtt ccgcggccgc cggtggaact gcaccaccgt ccacgacagc
 361 ctggccatct tcgggcccgt gctggacaaa gctaccaggg agtcggcctt tgtccacgcc
 421 attgcctcag ccggtgtggc ctttgcagtg acacgctcat gtgcagaagg cacggccgcc
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2581 cacagccctg agatgggccg gccccttcc tggcccctca tggcgggact ggagaaatgg
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2701 aatggggagg ccgctgaacc cacccggccc atatccctgg ttgcctcatg gccagcgccc
2761 ctcagcctct gccactgtga accggctccc accctcaagg tgcggggaga agaagcggcc
2821 aggcggggcg ccccaagagc ccaaaagagg gcacaccgcc atcctctgcc tcaaattctg
2881 cgtttttggt tttaatgtta tatctgatgc tgctatatcc actgtccaac gg
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**Sequence ID No. 3 Murine Wnt3a amino acid sequence**
**Accession: NM_009522**

MAPLGYLLVLCSLKQALGSYPIWWSLAVGPQYSSLSTQPILCASIPGLVPKQLRFCRNYVEIMPSVAEGVKA
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SPGEGWKWGGCSEDIEFGGMVSREFADARENRPDARSAMNRHNNEAGRQAIASHMHLKCKCHGLSGSCEVKT
CWWSQPDFRTIGDFLKDKYDSASEMVVEKHRESRGWVETLRPRYTYFKVPTERDLVYYEA
SPNFCEPNPETGSFGTRDRTCNVSSHGIDGCDLLCCGRGHNARTERRREKCHCVFHWCCYVSCQECTRVYDV
HTCK

**Sequence ID No. 4 Murine Wnt3a nucleotide sequence**

```
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 181 gcagctaccc gatctggtgg tccttggctg tgggacccca gtactcctct ctgagcactc
 241 agcccattct ctgtgccagc atcccaggcc tggtaccgaa gcagctgcgc ttctgcagga
 301 actacgtgga gatcatgccc agcgtggctg agggtgtcaa agcgggcatc caggagtgcc
 361 agcaccagtt ccgaggccgg cgttggaact gcaccaccgt cagcaacagc ctggccatct
 421 ttggccctgt tctggacaaa gccacccggg agtcagcctt tgtccatgcc atcgcctccg
 481 ctggagtagc tttcgcagtg acacgctcct gtgcagaggg atcagctgct atctgtgggt
 541 gcagcagccg cctccagggc tccccaggcg agggctggaa gtggggcggc tgtagtgagg
 601 acattgaatt tggaggaatg gtctctcggg agtttgccga tgccagggag aaccggccgg
 661 atgcccgctc tgccatgaac cgtcacaaca atgaggctgg gcgccaggcc atcgccagtc
 721 acatgcacct caagtgcaaa tgccacgggc tatctggcag ctgtgaagtg aagacctgct
 781 ggtggtcgca gccggacttc cgcaccatcg gggatttcct caaggacaag tatgacagtg
 841 cctcggagat ggtggtagag aaacaccgag agtctcgtgg ctgggtggag accctgaggc
 901 cacgttacac gtacttcaag gtgccgacag aacgcgacct ggtctactac gaggcctcac
 961 ccaacttctg cgaacctaac cccgaaaccg gctccttcgg gacgcgtgac cgcacctgca
1021 atgtgagctc gcatggcata gatgggtgcg acctgttgtg ctgcgggcgc gggcataacg
1081 cgcgcactga gcgacggagg gagaaatgcc actgtgtttt ccattggtgc tgctacgtca
1141 gctgccagga gtgcacacgt gtctatgacg tgcacacctg caagtaggag agctcctaac
1201 acgggagcag ggttcattcc gaggggcaag gttcctacct gggggcgggg ttcctacttg
1261 gaggggtctc ttacttgggg actcggttct tacttgaggg cggagatcct acctgtgagg
1321 gtctcatacc taaggacccg gtttctgcct tcagcctggg ctcctatttg ggatctgggt
1381 tccttttag gggagaagct cctgtctggg atacgggttt ctgcccgagg gtggggctcc
1441 acttggggat ggaattccaa tttgggccgg aagtcctacc tcaatggctt ggactcctct
1501 cttgacccga cagggctcaa atggagacag gtaagctact ccctcaacta ggtggggttc
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1621 agatacatga gagggtgctt cagggtgggc cctatttggg cttgaggatc ccgtgggggc
1681 ggggcttcac cccgactggg tggaactttt ggagacccca ttccactggg gcaaggcttc
1741 actgaagact catgggatgg agctccacgg aaggaggagt tcctgagcga gcctgggctc
1801 tgagcaggcc atccagctcc catctggccc ctttccagtc ctggtgtaag gttcaacctg
1861 caagcctcat ctgcgcagag caggatctcc tggcagaatg aggcatggag aagaactcag
1921 gggtgatacc aagacctaac aaaccccgtg cctgggtacc tcttttaaag ctctgcaccc
1981 cttcttcaag ggctttccta gtctccttgg cagagctttc ctgaggaaga tttgcagtcc
2041 cccagagttc aagtgaacac ccatagaaca gaacagactc tatcctgagt agagagggtt
2101 ctctaggaat ctctatgggg actgctagga aggatcctgg gcatgacagc ctcgtatgat
2161 agcctgcatc cgctctgaca cttaatactc agatctcccg ggaaacccag ctcatccggt
2221 ccgtgatgtc catgccccaa atgcctcaga gatgttgcct cactttgagt tgtatgaact
2281 tcggagacat ggggacacag tcaagccgca gagccagggt tgtttcagga cccatctgat
2341 tccccagagc ctgctgttga ggcaatggtc accagatccg ttggccacca ccctgtcccg
2401 agcttctcta gtgtctgtct ggcctggaag tgaggtgcta catacagccc atctgccaca
2461 agagcttcct gattggtacc actgtgaacc gtccctcccc ctccagacag gggaggggat
2521 gtggccatac aggagtgtgc ccggagagcg cggaaagagg aagagaggct gcacacgcgt
2581 ggtgactgac tgtcttctgc ctggaacttt gcgttcgcgc ttgtaacttt attttcaatg
2641 ctgctatatc cacccaccac tggatttaga caaaagtgat tttcttttt ttttttctt
2701 ttctttctat gaaagaaatt attttagttt atagtatgtt tgtttcaaat aatggggaaa
2761 gtaaaaagag agaaaaaaaa aaaaaaaaaa aaaaaaaaaa aaaaaaaaaa aaaa
```

**Sequence ID No. 5 Rat Wnt3a amino acid sequence**

MAPLGYLLELCSLKQALGSYPVWWSLAVGPQYSSLSTQPILCASIPGLVPKQLRFCRNYVEIMPSVAEGVKA
GIQECQHQFRGRRWNCTTVSNSLAIFGPVLDKATRESAFVHAIASAGVAFAVTRSCAEGSAAICGCSSRLQG
SPGEGWKWGGCSEDIEFGGMVSREFADARENRPDARSAMNRHNNEAGRQAIASHMHLKCKCHGLSGSCEVKT
CWWSQPDFRTIGDFLKDKYDSASEMVVEKHRESRGWVETLRPRYTYFKVPTERDLVYYEASPNFCEPNPETG
SFGTRDRTCNVSSHGIDGCDLLCCGRGHNARTERRREKCHCVFHWCCYVSCQECTRVYDVHTCK

**Sequence ID No. 6 Rat Wnt3a nucleotide sequence**

```
1    atggacgaaa ggagcatcaa cacttccaag aacaagagac aggatgtggc agtgctagcg
61   gggcactggc ctcggcccgc cgcccggccg ccggcccacc tggcgcagcg ccgccctcgg
121  agcccgtgta ccggtgcaca cccgggaacc ccgcgcaccc cgctgccaca gagggcccag
181  cgccactgca gccgcgccac ctcccagggc cgggccagcc ccggcgtacg cgctctcggg
241  gtggactccc cccgctgcgc gttcaagccc acgatggctc ctctcggata cctgttagag
301  ctctgcagcc tgaagcaggc gctgggcagc taccctgtgt ggtggtcctt ggctgtggga
361  ccccagtact cctcactgag cactcagccc attctctgtg ccagcatccc gggtctggtg
421  cccaagcagc tgcgcttctg caggaactac gtggagatca tgcccagtgt ggccgagggt
481  gtcaaggcgg gcatccaaga gtgccagcac cagttccgag gccggcgttg gaactgcacc
541  actgtcagca acagcctggc catctttggc cccgttctgg acaaagccac ccgggagtca
601  gcctttgtcc atgccatcgc ttccgctgga gtggccttcg cagtgacccg gtcctgtgca
661  gagggatcag ctgccatctg tgggtgcagc agccgcttgc agggctcccc aggcgagggc
721  tggaagtggg gtggctgtag tgaggacatt gaatttggag gaatggtctc tcgggagttt
781  gccgatgcca gggagaaccg gccggatgcc cgctctgcca tgaaccgtca caacaatgag
841  gctgggcgac aggccatcgc cagtcacatg cacctcaagt gcaaatgcca cggactatcc
901  ggcagttgcg aagtgaagac ctgctggtgg tcgcagcctg acttccgcac catcggggat
961  ttcctcaagg acaagtatga cagcgcctca gagatggtgg tagagaaaca ccgagagtct
1021 cgtggctggg tggagacctt gaggccacgt tacacatact tcaaggtgcc cacagagcgc
1081 gacctggtct actacgaggc ctcacctaac ttctgcgagc ccaaccctga aaccggctcc
1141 ttcgggacgc gtgaccgcac ctgcaatgtg agctcgcatg gcatagacgg gtgcgacctg
1201 ttgtgctgcg ggcgtgggca taacgcgcgc actgagcgac ggagggagaa atgccactgt
1261 gttttccact ggtgctgtta tgtcagctgc caggagtgca cacgtgtcta tgacgtgcac
1321 acctgcaagt aggagggctc ctaacagagg gagcagggtt cattcctcgg ggcaagattc
1381 ctat
```

**Comparison of Human Wnt3A protein sequence (query 1) and murine Wnt3a protein sequence (Subject 1)**

```
 Score =  689 bits (1777),  Expect = 0.0, Method: Composition-based stats.
 Identities = 338/352 (96%), Positives = 344/352 (97%), Gaps = 0/352 (0%)

Query  1    MAPLGYFLLLCSLKQALGSYPIWWSLAVGPQYSSLGSQPILCASIPGLVPKQLRFCRNYV  60
            MAPLGY L+LCSLKQALGSYPIWWSLAVGPQYSSL +QPILCASIPGLVPKQLRFCRNYV
Sbjct  1    MAPLGYLLVLCSLKQALGSYPIWWSLAVGPQYSSLSTQPILCASIPGLVPKQLRFCRNYV  60

Query  61   EIMPSVAEGIKIGIQECQHQFRGRRWNCTTVHDSLAIFGPVLDKATRESAFVHAIASAGV  120
            EIMPSVAEG+K GIQECQHQFRGRRWNCTTV +SLAIFGPVLDKATRESAFVHAIASAGV
Sbjct  61   EIMPSVAEGVKAGIQECQHQFRGRRWNCTTVSNSLAIFGPVLDKATRESAFVHAIASAGV  120

Query  121  AFAVTRSCAEGTAAICGCSSRHQGSPGKGWKWGGCSEDIEFGGMVSREFADARENRPDAR  180
            AFAVTRSCAEG+AAICGCSSR QGSPG+GWKWGGCSEDIEFGGMVSREFADARENRPDAR
Sbjct  121  AFAVTRSCAEGSAAICGCSSRLQGSPGEGWKWGGCSEDIEFGGMVSREFADARENRPDAR  180

Query  181  SAMNRHNNEAGRQAIASHMHLKCKCHGLSGSCEVKTCWWSQPDFRAIGDFLKDKYDSASE  240
            SAMNRHNNEAGRQAIASHMHLKCKCHGLSGSCEVKTCWWSQPDFR IGDFLKDKYDSASE
Sbjct  181  SAMNRHNNEAGRQAIASHMHLKCKCHGLSGSCEVKTCWWSQPDFRTIGDFLKDKYDSASE  240

Query  241  MVVEKHRESRGWVETLRPRYTYFKVPTERDLVYYEASPNFCEPNPETGSFGTRDRTCNVS  300
            MVVEKHRESRGWVETLRPRYTYFKVPTERDLVYYEASPNFCEPNPETGSFGTRDRTCNVS
Sbjct  241  MVVEKHRESRGWVETLRPRYTYFKVPTERDLVYYEASPNFCEPNPETGSFGTRDRTCNVS  300
```

```
Query  301  SHGIDGCDLLCCGRGHNARAERRREKCRCVFHWCCYVSCQECTRVYDVHTCK  352
            SHGIDGCDLLCCGRGHNAR ERRREKC CVFHWCCYVSCQECTRVYDVHTCK
Sbjct  301  SHGIDGCDLLCCGRGHNARTERRREKCHCVFHWCCYVSCQECTRVYDVHTCK  352
```

**Comparison of Human Wnt3A protein sequence (query 1) and Rat Wnt3a protein sequence (Sequence ID No. 5; Subject 1)**

```
 Score =  686 bits (1770),  Expect = 0.0, Method: Composition-based stats.
 Identities = 337/352 (95%), Positives = 343/352 (97%), Gaps = 0/352 (0%)

Query  1    MAPLGYFLLLCSLKQALGSYPIWWSLAVGPQYSSLGSQPILCASIPGLVPKQLRFCRNYV  60
            MAPLGY L LCSLKQALGSYP+WWSLAVGPQYSSL +QPILCASIPGLVPKQLRFCRNYV
Sbjct  92   MAPLGYLLELCSLKQALGSYPVWWSLAVGPQYSSLSTQPILCASIPGLVPKQLRFCRNYV  151

Query  61   EIMPSVAEGIKIGIQECQHQFRGRRWNCTTVHDSLAIFGPVLDKATRESAFVHAIASAGV  120
            EIMPSVAEG+K GIQECQHQFRGRRWNCTTV +SLAIFGPVLDKATRESAFVHAIASAGV
Sbjct  152  EIMPSVAEGVKAGIQECQHQFRGRRWNCTTVSNSLAIFGPVLDKATRESAFVHAIASAGV  211

Query  121  AFAVTRSCAEGTAAICGCSSRHQGSPGKGWKWGGCSEDIEFGGMVSREFADARENRPDAR  180
            AFAVTRSCAEG+AAICGCSSR QGSPG+GWKWGGCSEDIEFGGMVSREFADARENRPDAR
Sbjct  212  AFAVTRSCAEGSAAICGCSSRLQGSPGEGWKWGGCSEDIEFGGMVSREFADARENRPDAR  271

Query  181  SAMNRHNNEAGRQAIASHMHLKCKCHGLSGSCEVKTCWWSQPDFRAIGDFLKDKYDSASE  240
            SAMNRHNNEAGRQAIASHMHLKCKCHGLSGSCEVKTCWWSQPDFR IGDFLKDKYDSASE
Sbjct  272  SAMNRHNNEAGRQAIASHMHLKCKCHGLSGSCEVKTCWWSQPDFRTIGDFLKDKYDSASE  331

Query  241  MVVEKHRESRGWVETLRPRYTYFKVPTERDLVYYEASPNFCEPNPETGSFGTRDRTCNVS  300
            MVVEKHRESRGWVETLRPRYTYFKVPTERDLVYYEASPNFCEPNPETGSFGTRDRTCNVS
Sbjct  332  MVVEKHRESRGWVETLRPRYTYFKVPTERDLVYYEASPNFCEPNPETGSFGTRDRTCNVS  391

Query  301  SHGIDGCDLLCCGRGHNARAERRREKCRCVFHWCCYVSCQECTRVYDVHTCK  352
            SHGIDGCDLLCCGRGHNAR ERRREKC CVFHWCCYVSCQECTRVYDVHTCK
Sbjct  392  SHGIDGCDLLCCGRGHNARTERRREKCHCVFHWCCYVSCQECTRVYDVHTCK  443
```

**Nucleotide sequence of human LRP5 (Sequence ID No. 7)**

```
   1 atggagcccg agtgagcgcg gcgcgggccc gtccggccgc cggacaacat ggaggcagcg
  61 ccgcccgggc cgccgtggcc gctgctgctg ctgctgctgc tgctgctggc gctgtgcggc
 121 tgcccggccc ccgccgcggc ctcgccgctc ctgctatttg ccaaccgccg ggacgtacgg
 181 ctggtggacg ccggcggagt caagctggag tccaccatcg tggtcagcgg cctggaggat
 241 gcggccgcag tggacttcca gttttccaag ggagccgtgt actggacaga cgtgagcgag
 301 gaggccatca agcagaccta cctgaaccag acgggggccg ccgtgcagaa cgtggtcatc
 361 tccggcctgg tctctcccga cggcctcgcc tgcgactggg tgggcaagaa gctgtactgg
 421 acggactcag agaccaaccg catcgaggtg gccaacctca atggcacatc ccggaaggtg
 481 ctcttctggc aggaccttga ccagccgagg gccatcgcct tggaccccgc tcacgggtac
 541 atgtactgga cagactgggg tgagacgccc cggattgagc gggcagggat ggatggcagc
 601 acccggaaga tcattgtgga ctcggacatt tactggccca atggactgac catcgacctg
 661 gaggagcaga agctctactg ggctgacgcc aagctcagct tcatccaccg tgccaacctg
 721 gacggctcgt tccggcagaa ggtggtggag ggcagcctga cgcacccctt cgccctgacg
 781 ctctccgggg acactctgta ctggacagac tggcagaccc gctccatcca tgcctgcaac
 841 aagcgcactg gggggaagag gaaggagatc ctgagtgccc tctactcacc catggacatc
 901 caggtgctga gccaggagcg gcagcctttc ttccacactc gctgtgagga ggacaatggc
 961 ggctgctccc acctgtgcct gctgtcccca agcgagcctt tctacacatg cgcctgcccc
1021 acgggtgtgc agctgcagga caacggcagg acgtgtaagg caggagccga ggaggtgctg
1081 ctgctggccc ggcggacgga cctacggagg atctcgctgg acacgccgga ctttaccgac
1141 atcgtgctgc aggtggacga catccggcac gccattgcca tcgactacga cccgctagag
1201 ggctatgtct actggacaga tgacgaggtg cgggccatcc gcagggcgta cctggacggg
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1321 tgggtggccc gaaacctcta ctggaccgac acgggcacgg accgcatcga ggtgacgcgc
1381 ctcaacggca cctcccgcaa gatcctggtg tcggaggacc tggacgagcc ccgagccatc
1441 gcactgcacc ccgtgatggg cctcatgtac tggacagact ggggagagaa ccctaaaatc
1501 gagtgtgcca acttggatgg gcaggagcgg cgtgtgctgg tcaatgcctc cctcgggtgg
1561 cccaacggcc tggccctgga cctgcaggag gggaagctct actggggaga cgccaagaca
1621 gacaagatcg aggtgatcaa tgttgatggg acgaagaggc ggaccctcct ggaggacaag
1681 ctcccgcaca ttttcgggtt cacgctgctg ggggacttca tctactggac tgactggcag
1741 cgccgcagca tcgagcgggt gcacaaggtc aaggccagcc gggacgtcat cattgaccag
1801 ctgcccgacc tgatggggct caaagctgtg aatgtggcca aggtcgtcgg aaccaacccg
1861 tgtgcggaca ggaacggggg gtgcagccac ctgtgcttct tcacacccca cgcaacccgg
1921 tgtggctgcc ccatcggcct ggagctgctg agtgacatga agacctgcat cgtgcctgag
```

```
1981 gccttcttgg tcttcaccag cagagccgcc atccacagga tctccctcga gaccaataac
2041 aacgacgtgg ccatcccgct cacgggcgtc aaggaggcct cagccctgga ctttgatgtg
2101 tccaacaacc acatctactg gacagacgtc agcctgaaga ccatcagccg cgccttcatg
2161 aacgggagct cggtggagca cgtggtggag tttggccttg actaccccga gggcatggcc
2221 gttgactgga tgggcaagaa cctctactgg gccgacactg ggaccaacag aatcgaagtg
2281 gcgcggctgg acgggcagtt ccggcaagtc ctcgtgtgga gggacttgga caacccgagg
2341 tcgctggccc tggatcccac caagggctac atctactgga ccgagtgggg cggcaagccg
2401 aggatcgtgc gggccttcat ggacgggacc aactgcatga cgctggtgga caaggtgggc
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2521 accaacatga tcgagtcgtc caacatgctg ggtcaggagc gggtcgtgat tgccgacgat
2581 ctcccgcacc cgttcggtct gacgcagtac agcgattata tctactggac agactggaat
2641 ctgcacagca ttgagcgggc cgacaagact agcggccgga accgcaccct catccagggc
2701 cacctggact tcgtgatgga catcctggtg ttccactcct cccgccagga tggcctcaat
2761 gactgtatgc acaacaacgg gcagtgtggg cagctgtgcc ttgccatccc cggcggccac
2821 cgctgcggct gcgcctcaca ctacaccctg gaccccagca gccgcaactg cagcccgccc
2881 accaccttct tgctgttcag ccagaaatct gccatcagtc ggatgatccc ggacgaccag
2941 cacagcccgg atctcatcct gcccctgcat ggactgagga acgtcaaagc catcgactat
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3121 cagccccacg acctcagcat cgacatctac agccggacac tgttctggac gtgcgaggcc
3181 accaatacca tcaacgtcca caggctgagc ggggaagcca tgggggtggt gctgcgtggg
3241 gaccgcgaca agcccagggc catcgtcgtc aacgcggagc gagggtacct gtacttcacc
3301 aacatgcagg accgggcagc caagatcgaa cgcgcagccc tggacggcac cgagcgcgag
3361 gtcctcttca ccaccggcct catccgccct gtggccctgg tggtagacaa cacactgggc
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3481 aaccgcctga ccctggagga cgccaacatc gtgcagcctc tgggcctgac catccttggc
3541 aagcatctct actggatcga ccgccagcag cagatgatcg agcgtgtgga gaagaccacc
3601 ggggacaagc ggactcgcat ccagggccgt gtcgcccacc tcactggcat ccatgcagtg
3661 gaggaagtca gcctggagga gttctcagcc cacccatgtg cccgtgacaa tggtggctgc
3721 tcccacatct gtattgccaa gggtgatggg acaccacggt gctcatgccc agtccacctc
3781 gtgctcctgc agaacctgct gacctgtgga gagccgccca cctgctcccc ggaccagttt
3841 gcatgtgcca caggggagat cgactgtatc cccggggcct ggcgctgtga cggctttccc
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4081 agcggccagt gtgtcctcat caaacagcag tgcgactcct tccccgactg tatcgacggc
4141 tccgacgagc tcatgtgtga aatcaccaag ccgccctcag acgacagccc ggcccacagc
4201 agtgccatcg ggcccgtcat tggcatcatc ctctctctct tcgtcatggg tggtgtctat
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4321 gagtatgtca gcgggacccc gcacgtgccc ctcaatttca tagccccggg cggttcccag
4381 catggccccc tcacaggcat cgcatgcgga aagtccatga tgagctccgt gagcctgatg
4441 gggggccggg gcggggtgcc cctctacgac cggaaccacg tcacaggggc ctcgtccagc
4501 agctcgtcca gcacgaaggc cacgctgtac ccgccgatcc tgaacccgcc gccctccccg
4561 gccacggacc cctccctgta caacatggac atgttctact cttcaaacat tccggccact
4621 gtgagaccgt acaggcccta catcattcga ggaatggcgc ccccgacgac gccctgcagc
4681 accgacgtgt gtgacagcga ctacagcgcc agccgctgga aggccagcaa gtactacctg
4741 gatttgaact cggactcaga cccctatcca cccccaccca cgccccacag ccagtacctg
4801 tcggcggagg acagctgccc gccctcgccc gccaccgaga ggagctactt ccatctcttc
4861 ccgcccccctc cgtcccccctg cacggactca tcctgacctc ggccgggcca ctctggcttc
4921 tctgtgcccc tgtaaatagt tttaaatatg aacaaagaaa aaaatatatt ttatgattta
4981 aaaaataaat ataattggga ttttaaaaac atgagaaatg tgaactgtga tggggtgggc
5041 agggctggga gaactttgta cagtggaaca aatatttata aacttaattt tgtaaaacag
```

**Amino Acid sequence of LRP5 (Sequence ID No. 8)**

```
MEAAPPGPPWPLLLLLLLLLALCGCPAPAAASPLLLFANRRDVRLVDAGGVKLESTIVVSGLEDAAAVDFQF
SKGAVYWTDVSEEAIKQTYLNQTGAAVQNVVISGLVSPDGLACDWVGKKLYWTDSETNRIEVANLNGTSRKV
LFWQDLDQPRAIALDPAHGYMYWTDWGETPRIERAGMDGSTRKIIVDSDIYWPNGLTIDLEEQKLYWADAKL
SFIHRANLDGSFRQKVVEGSLTHPFALTLSGDTLYWTDWQTRSIHACNKRTGGKRKEILS
ALYSPMDIQVLSQERQPFFHTRCEEDNGGCSHLCLLSPSEPFYTCACPTGVQLQDNGRTCKAGAEEVLLLAR
RTDLRRISLDTPDFTDIVLQVDDIRHAIAIDYDPLEGYVYWTDDEVRAIRRAYLDGSGAQTLVNTEINDPDG
IAVDWVARNLYWTDTGTDRIEVTRLNGTSRKILVSEDLDEPRAIALHPVMGLMYWTDWGENPKIECANLDGQ
ERRVLVNASLGWPNGLALDLQEGKLYWGDAKTDKIEVINVDGTKRRTLLEDKLPHIFGFTLLGDFIYWTDWQ
RRSIERVHKVKASRDVIIDQLPDLMGLKAVNVAKVVGTNPCADRNGGCSHLCFFTPHATRCGCPIGLELLSD
MKTCIVPEAFLVFTSRAAIHRISLETNNNDVAIPLTGVKEASALDFDVSNNHIYWTDVSLKTISRAFMNGSS
VEHVVEFGLDYPEGMAVDWMGKNLYWADTGTNRIEVARLDGQFRQVLVWRDLDNPRSLALDPTKGYIYWTEW
GGKPRIVRAFMDGTNCMTLVDKVGRANDLTIDYADQRLYWTDLDTNMIESSNMLGQERVVIADDLPHPFGLT
QYSDYIYWTDWNLHSIERADKTSGRNRTLIQGHLDFVMDILVFHSSRQDGLNDCMHNNGQCGQLCLAIPGGH
RCGCASHYTLDPSSRNCSPPTTFLLFSQKSAISRMIPDDQHSPDLILPLHGLRNVKAIDYDPLDKFIYWVDG
```

RQNIKRAKDDGTQPFVLTSLSQGQNPDRQPHDLSIDIYSRTLFWTCEATNTINVHRLSGEAMGVVLRGDRDK
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LSGANRLTLEDANIVQPLGLTILGKHLYWIDRQQQMIERVEKTTGDKRTRIQGRVAHLTGIHAVEEVSLEEF
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## Nucleotide Sequence of human LRP6 (Sequence ID No. 9)

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2041 ctattccact cactggtgtc aaagaagctt ctgctttgga ttttgatgtg acagacaacc
2101 gaatttattg gactgatata tcactcaaga ccatcagcag agcctttatg aatggcagtg
2161 cactggaaca tgtggtagaa ttcggcttag attatccaga aggcatggca gtagactggc
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```

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4381 ctcttccagg aatgtctcga ggtaaatcaa tgatcagctc cctcagtatc atgggggaa
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4501 gcaccaaagg cacttacttc cctgcaattt tgaaccctcc accatcccca gccacagagc
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5281 ttgataccaa aaaaaaaaaa a
```

**Amino acid sequence of human LRP6 (Sequence ID No. 10)**

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LDPSSGFMYWTDWGEVPKIERAGMDGSSRFIIINSEIYWPNGLTLDYEEQKLYWADAKLNFIHKSNLDGTNR
QAVVKGSLPHPFALTLFEDILYWTDWSTHSILACNKYTGEGLREIHSDIFSPMDIHAFSQ
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EFGYSSNSPSTHRSYSYRPYSYRHFAPPTTPCSTDVCDSDYAPSRRMTSVATAKGYTSDLNYDSEPVPPPPT
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```

**Nucleotide sequence of human Frizzled 8 (FZD8) (Sequence ID No. 11)**

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 121 ccgtgccgct gtgtaagggc atcggctaca actacaccta catgcccaat cagttcaacc
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```

```
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 481 ccgcgcccag cccgccgcgc cgcctgccgc cgccgccgcc cggcgagcag ccgccttcgg
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3061 ctcttttctg atccatggat aacaactctc actttagtgg atgtaaatgg aacttctgca
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3181 aaccctgaaa aaaaa
```

**Amino acid sequence human Frizzled 8 (FZD8) (Sequence ID No. 12)**

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KARPPGGGAAPCEPGCQCRAPMVSVSSERHPLYNRVKTGQIANCALPCHNPFFSQDERAF
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## CLAIMS

1. WNT3A, or a therapeutically effective fragment or derivative thereof, for use as a medicament for the prevention, reduction or inhibition of scarring.

2. WNT3A, or a therapeutically effective fragment or derivative thereof, according to claim 1, for use wherein the medicament provides a therapeutically effective amount of WNT3A, or the fragment or derivative thereof.

3. WNT3A, or a therapeutically effective fragment or derivative thereof, according to any claim 1 or claim 2, for use wherein the scarring is scarring that results from healing of a wound.

4. WNT3A, or a therapeutically effective fragment or derivative thereof, according to any preceding claim, for use wherein the scarring occurs in a tissue selected from the group consisting of: the skin; the eye; tendons, ligaments or muscle; the oral cavity, lips and palate; the liver; the heart; digestive tissues; reproductive tissues; the abdominal cavity; the central and peripheral nervous system; the pelvic cavity and the thoracic cavity.

5. WNT3A, or a therapeutically effective fragment or derivative thereof, according to any preceding claim, for use wherein the scarring is associated with a fibrotic disorder.

6. WNT3A, or a therapeutically effective fragment or derivative thereof, according to claim 5, for use wherein the fibrotic disorder is selected from the group consisting of: skin fibrosis; scleroderma; progressive systemic fibrosis; lung fibrosis; muscle fibrosis; kidney fibrosis; glomerulosclerosis; glomerulonephritis; uterine fibrosis; renal fibrosis; cirrhosis of the liver, liver fibrosis; adhesions, such as those occurring in the abdomen, pelvis, spine or tendons; chronic obstructive pulmonary disease; fibrosis following myocardial infarction; fibrosis associated with proliferative vitreoretinopathy (PVR); endometriosis; ischemic disease and radiation fibrosis.

7. WNT3A, or a therapeutically effective fragment or derivative thereof, according to any preceding claim, for use wherein the medicament is for use in the prevention, reduction or inhibition of scarring of the skin.

8. WNT3A, or a therapeutically effective fragment or derivative thereof, according to any one of claims 1 to 6, for use wherein the medicament is for use in the prevention, reduction or inhibition of scarring in the eye.

9. WNT3A, or a therapeutically effective fragment or derivative thereof, according to any one of claims 1 to 6, wherein the medicament is for use in the prevention, reduction or inhibition of adhesions, such as those occurring in the abdomen, pelvis, spine or tendons.

10. WNT3A, or a therapeutically effective fragment or derivative thereof, according to any preceding claim, for use wherein the medicament is a topical medicament.

11. WNT3A, or a therapeutically effective fragment or derivative thereof, according to any preceding claim, for use wherein the medicament is an injectable solution.

12. WNT3A, or a therapeutically effective fragment or derivative thereof, according to claim 11, for use wherein the medicament is for intradermal injection.

13. WNT3A according to any preceding claim, for use as a medicament for the prevention, reduction or inhibition of scarring.

14. A derivative of WNT3A according to any one of claims 1 to 12, for use as a medicament for the prevention, reduction or inhibition of scarring.

15. A derivative of WNT3A according to claim 14, wherein the derivative of WNT3A has increased resistance to degradation compared to WNT3A.

16. A derivative of WNT3A according to claim 14 or claim 15, wherein the derivative of WNT3A is a peptoid derivative.

17. WNT3A, or a therapeutically effective fragment or derivative thereof, according to any preceding claim, for use wherein the medicament provides approximately 1ng of WNT3A, or a fragment or derivative thereof, per centimetre of wound or fibrosis.

18. A method of preventing, reducing or inhibiting scarring, the method comprising administering a therapeutically effective amount of WNT3A, or a therapeutically effective fragment or derivative thereof, to a patient in need of such prevention, reduction or inhibition.

*Figure 1.*

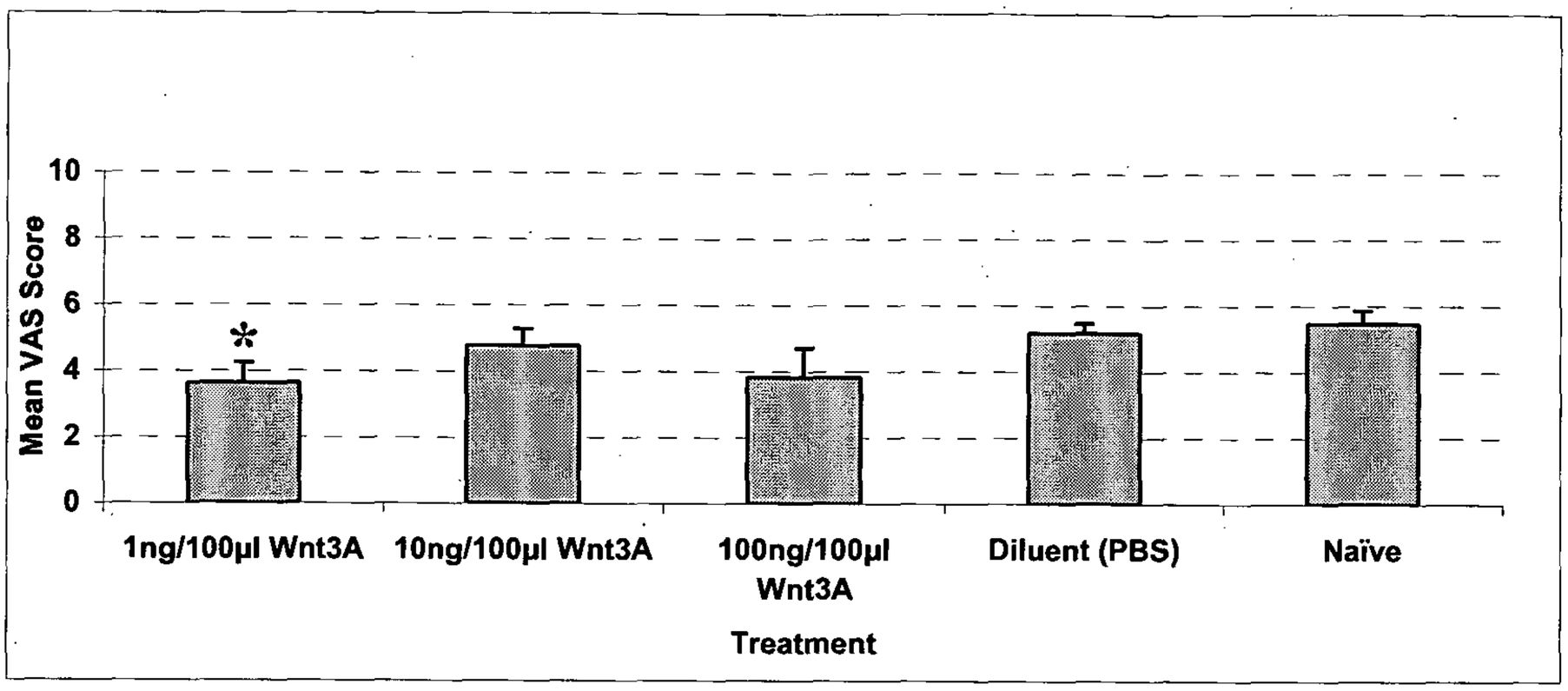



*Figure 2*

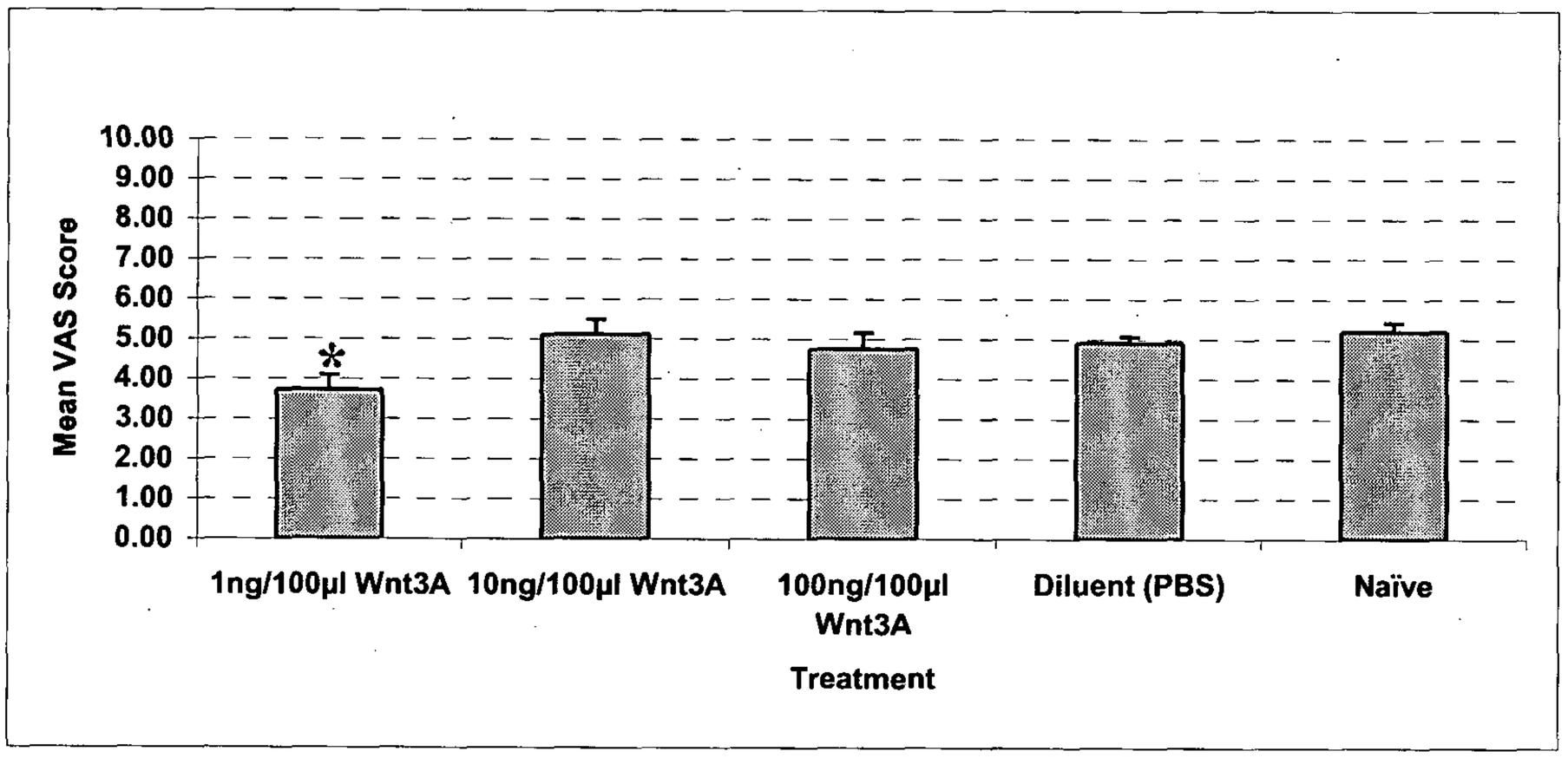
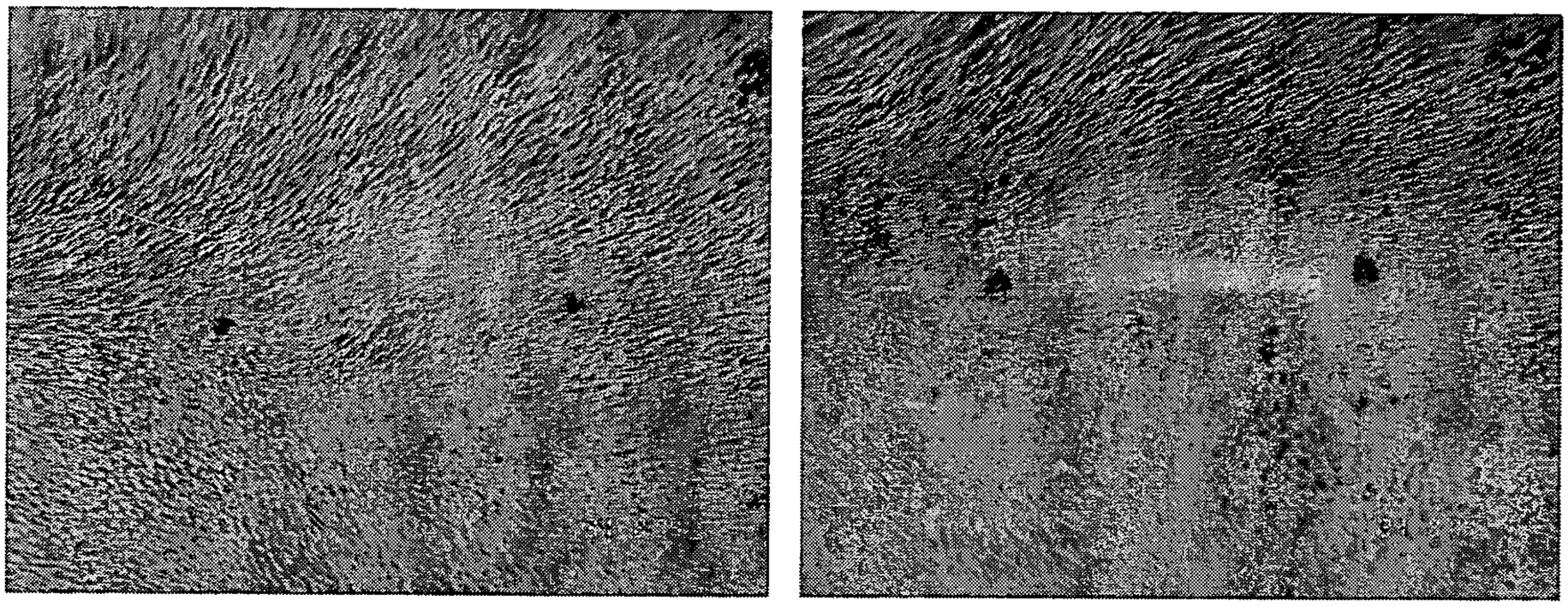


***Figure 3***



**A** **B**